Annual Report of the

Board of Scientific Advice for India

for the year 1914-15

Calcutta
Superintendent Government Printing, India
1916

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The Hon'ble Mr. R. P. Russell, C.S.I.	Secretary to the Government of India, Public Works Department.
Major A. T. Gage, I.M.S. .	Director of the Botanical Survey of India and Secretary, Board of Scientific Advice.

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3. The Director, Geological Survey of India.

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3. The Inspector-General of Forests.

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3. The Director, Geological Survey of India;
4. The Superintendent of the Indian Museum.

ANNUAL REPORT FOR 1914-15.

ANNUAL REPORT

OF THE

BOARD OF SCIENTIFIC ADVICE FOR INDIA

1914-15.

SUMMARY OF PROCEEDINGS.

Twenty-eighth Meeting held at Simla on the 10th May 1915.

The Board considered the programmes for 1915-16 of the various Scientific Departments. It was resolved that in future condensed programmes should be submitted to the Board, regard being paid mainly to scientific investigations; that excessive detail in programmes should be avoided, general lines of inquiry only being described; that subject to the detailed examination of the agricultural programme by the Board of Agriculture, the programmes of the various Departments be accepted.

Twenty-ninth Meeting held at Delhi on the 11th November 1915.

The Board discussed the question—referred to it by the Government of India—of continuing the privilege of selected officers from the various provinces of India attending the Meetings of the India Science Congress on duty. It was resolved to recommend that the concession that selected officers should be permitted to attend the India Science Congress on duty should be extended to the Meeting to be held in January 1916. The Board preferred to reserve expression of opinion regarding the necessity for holding annual meetings of the Congress until after the next Meeting when several members of the Board would have had experience of the working of the Congress. The draft Annual Report of the Board for 1914-15 and the revised Distribution List of the Report were accepted subject to minor emendations in the former.

The request made by the Asiatic Society of Bengal that Government should meet the cost of publication of the Catalogue of Scientific Serial publications in the principal Libraries of Calcutta which had been prepared by the Society was referred by Government to the Board for consideration. The Board was

of opinion that the Catalogue should be of great use to Government Scientific Departments and to scientific workers generally, and recommended that the request of the Asiatic Society of Bengal that the cost of the publication of the Catalogue should be met by the Government of India on the terms regarding sale and distribution proposed by the Society should be granted. In this connection the Board was of opinion that the desirability of relaxing the rules in any Government library where they do not permit books or papers to be lent out at the discretion of the head of the Department should be considered.

The Board considered a letter from the Principal of the Punjab Veterinary College urging the importance of having experiments carried out to determine the vitality of Rinderpest virus in India.

It was resolved to recommend that a complete series of experiments under varying conditions to test the vitality of Rinderpest virus in India should be undertaken at the Imperial Bacteriological Laboratory.

APPLIED CHEMISTRY.

PART I.—AGRICULTURAL CHEMISTRY

BY

J. WALTER LEATHER, Ph.D., F.I.C., V.D.,

Imperial Agricultural Chemist.

SOILS.

Soil temperatures.—In Memoir, Department of Agriculture in India, Chemical Series, Volume IV, No. 2, J. W. Leather has published the records of soil temperature which have been maintained at Pusa for several years in bare-fallow soil and in soil-bearing crops. The following are the general conclusions :—

1. The temperature of the surface soil naturally varies both with the hour of the day and with the season.

2. The *seasonal* variation. The minima are in January and the maxima in May.

In bare-fallow soil.

3. The *diurnal* change of temperature extends to between 12 ″ and 24″ from the surface on most days in the year. About 12 ″ it amounts to about 1°C, but at 24 ″ it is doubtful whether it ever exceeds 0·1°C in Bihar and probably does not exceed 0·2°C in any part of India.

4. There is a fairly close correspondence between the temperature of *bare-fallow soil* at 1 ″ from the surface and that of the *air in the shade* ; approximately the soil minimum at this depth is about 2·0°C higher than the air minimum, and the soil maximum is about 3·0°C higher than the air maximum.

5. There is also a similarly close relation between the *diurnal change* of temperature in the *soil* (bare-fallow) at 1″ from the surface and in the *air* (shade), the diurnal change being about 1·5°C. greater in the soil at this depth than in the air. This *diurnal change* is least during the monsoon and greatest during the dry season ; at the former season (June to September) it is about 10° C. in the soil (bare-fallow) at 1″ deep, and during the latter (in March and April) it frequently approaches 20°C.

6. The temperature of the soil near the surface (down to 3″ or 4″) is above the mean temperature for only about 8 hours daily, whilst it is below it for about 16 hours.

7. The *lag* in temperature is about 2 hours at 3″ deep and about 8 hours at 18″ from the surface.

8. A change in the specific heat of the soil, due to change of moisture content, does not seem to affect the maxima or minima ; but rainfalls during the dry season, causing a considerable change in the amount of water evaporating, have a marked effect.

9. It is possible to estimate approximately the temperature to which the soil rises under specified conditions in other parts of India.

In cropped land.

10. The effect of a covering crop on the soil-temperature is naturally very marked, for it both prevents the surface soil from rising to the temperature which fallow land assumes, and also modifies the diurnal change. Thus whilst the temperature of exposed soil at 1″ deep rises to about 3°C. *above* that of the air, that of cropped land is about 2°C. below it ; and whilst the temperature of exposed soil *at the surface* rises to probably some 20° C. above that of the air, the corresponding figure for cropped land is only some 2° or 3°C. even in March, whilst in the rains it is actually lower than that of the air. Also in respect of diurnal change ; at 1″ deep, whilst exposed soil suffers a change of some 20°C. in March, that of cropped land is only about 13°C. at the same depth ; and during the monsoon whilst exposed soil suffers a diurnal change of some 10°C. at 1″ deep, that of cropped land is only about 3° to 4°C.

WATERS.

The Journal of the Royal Asiatic Society (1914) contains an account of some intermittent springs which occur near the town Rajapur, District Ratngiri, in the Western Ghats, and which have been partially examined by H. H. Mann and S. R. Paranjpe. These springs flow only periodically, about once in two years, and then only for a period of 20 to 50 days. The flow does not appear to be directly associated with any particular season. The temperature of all, with one exception, is about 28° to 31°C., but one of them has a temperature of about 43°C. The water is comparatively soft, and contains about 25 to 35 parts of saline matters per 100,000 parts of water. The salts include principally sodium carbonate, sulphate and chloride with lesser quantities of lime and magnesia salts. They are all slightly alkaline. The hot spring is not characteristically different from the others in chemical composition.

CROPS.

Moisture in wheat.—In the course of investigations on the conditions which accompany the attacks of weevil on wheat, J. H. Barnes found that dry wheat takes up little or no moisture from a damp atmosphere.

Effect of carbon dioxide on wheat.—In the course of the same investigation J. H. Barnes found that carbon dioxide has a marked effect on the vitality of stored wheat, the germinating power being rapidly destroyed.

Sugarcane.—In Bulletin No. 49 of the Agricultural Research Institute, H. E. Annett gives an account of a series of tests made at Dacca of the error experienced when sampling sugarcane in the field. Several different methods were employed on a number of plots which resulted in showing that in order to reduce the experimental error as far as possible, cane must be taken from a number of different places in the field, at fixed intervals, and he concludes that the method described by Leather in Memoir, Department of Agriculture in India, Chemical Series, Vol. III, No. 4, gives the best results. The tests also showed that the cane on these plots was less uniform than what may be generally expected.

Acid secretion of Cicer arietinum.—In Bulletin No. 45 of the Agricultural Research Institute, D. L. Sahasrabuddhe gives an account of experiments on the quantity of acid secretion which occurs in the gram plant. The acidity is principally due to malic and oxalic acids, chiefly the former. It occurs chiefly on the pods, but is also found on the leaf, and appears to be excreted daily. The author estimated that 1,343 grams of malic acid was found per acre of plant between the 14th and 18th weeks of growth.

Tea.—An examination of samples of tea made at the instance of the Department of Commerce and Industry by J. H. Barnes, showed some of them to be very badly adulterated, one sample containing 40 per cent. of earth in addition to the presence of a yellow aniline dye.

FATS.

The "fat" of *Garcinia indica*, "Kokam butter", has been examined by H. H. Mann and N. V. Kanitkar who found its composition to be similar to that found by D. Hooper (Jour. Asiatic Soc. Bengal, III, p. 257) excepting that whilst Hooper found a comparatively high acid value, the samples examined by Messrs. Mann and Kanitkar contained only small amounts and they attribute the high proportions met with by Hooper to the "butter" becoming rancid. They found a small amount of volatile fatty acid, after saponification, which is stated to be a mixture of acetic and propionic acids in about equal proportions. Butyric acid was absent.

Goats' fat.—Since goats' fat has been recently imported into the Poona bazar, apparently for use as an adulterant of ghee, H. H. Mann and N. V. Kanitkar have examined samples of it and the analyses have been published in the Journal of Medical Research. The fat is very similar to mutton fat.

List of Publications.

ANNETT, H. E. . . The urease content of certain Indian seeds. (*Biochemical Journal, viii, (1914)*.

ANNETT, H. E. . . The experimental error in field trials with sugarcane, and the effect on this error of various methods of sampling. (*Agric. Research Institute, Bulletin No. 49*).

BARNES, J. H. . . *Annual Report of the Agricultural Chemist, Punjab*, 1914-15 (references to wheat and tea).

CLARKE, G. . . . Phytin and phytic acid. (*Trans. Chemical Society, 1914*).

LEATHER, J. W. . . Soil temperatures. (*Mem. Dept. Agric. in India, Chemical Series, iv, No. 2*).

MANN, H. H. & PARANJPE, S. R. Intermittent springs at Rajapur in the Bombay Presidency. (*Journ. Roy. Asiatic Soc., 1915.*)

MANN, H. H. & KANITKAR, N. V. Goats' fat as an adulterant of ghee. (*Journal of Medical Research, 1914.*)

,, ... Notes on the fat of Garcinia indica, the so-called Kokam butter. (*Journal of Asiatic Society, Bengal, x,* 1914.)

SAHASRABUDDHE, D. L. . The acid secretion of the gram plant. (*Agricultural Research Institute Bulletin, No. 45.*)

PART II.—FOREST CHEMISTRY.

BY

PURAN SINGH, F.C.S.,

Chemical Adviser to Forest Research Institute.

The following is a brief account of the more important work carried out by the Chemical Department of the Forest Research Institute during the year :—

Minor Products obtained from Deodar, their values and uses.— The steam distilled Deodar oil alluded to in the last year's report consists mostly of sesquiterpenes of characteristic odour. It is partly due to this oil that Deodar is an ant-proof timber. It was sent to Messrs. Schimmel & Co., Leipzig, and to the Imperial Institute, London, for valuation and for suggestion as to its possible uses. The reports received suggest no use for it. It was also sent to Kasauli Institute for examination as a germicide. It is reported to have a slight inhibitory effect but is weaker in this respect than many other essential oils.

A very interesting use has recently been suggested for it for perfuming leather, imparting to it a characteristic Deodar odour. The best method for using it as such is under investigation.

Optical rotation of steam-distilled Deodar Oil.—In last year's report of the Board of Scientific Advice p. 17, the results of the optical rotation given therein ought to be with the sign + which has been misprinted in two places as — and in one case is altogether missing. The constant of the Deodar oil as obtained in this Laboratory and those obtained by Messrs. Schimmel & Co., Leipzig, and the Imperial Institute, London, are in fair agreement except in the case of optical rotation. The optical rotation recorded for this oil by the Imperial Institute, London, is + 52° 16′ and that by Messrs. Schimmel & Co., is + 53° 8′. The optical rotation as determined last year in this Laboratory was however only + 33° 6′. In order to explain this difference, fresh observations were taken on a fresh sample of the Deodar oil, distilled in the distillery both on the (1) crude oil and (2) the redistilled oil, and also (3) on the oil distilled in October 1913 which was sent to London and Leipzig. This time the observations were made with a new superior type Laurent's half shadow polarimeter in place of the simple kind of apparatus used last year. The results obtained at the room temperature of about 30°C are :—

	Optical rotation in 100 mm. tube.
No. (1) crude oil	+29°36′
No. (2) Redistilled oil	+29° 9′
No. (3) About 20 months old oil (crude)	+29°30′

It seems that the optical rotation of the oil changes with the temperature. For example, oil No. (2) was cooled down to 4°C and observed as quickly as possible when the optical rotation rose to + 30°. It will be seen that the readings taken at Dehra Dun are still different from those recorded in Europe. On the invitation of the Chemical Adviser, the optical rotation of this oil was also observed by Dr. Khudadad, Ph.D., (Organic Chemistry) of Munich, Chemist to Messrs. Dixon Chemical Co., Dehra Dun, with identical results. The polarimeter was further tested by observing a sugar solution. There seems to be no doubt as to the accuracy of readings taken at Dehra Dun. It is, however, curious that the results obtained at three different places are so divergent. The only explanation that suggests itself is the change of the optical rotation of the oil through storage in the cold in Europe.

Dry Distillation of Deodar.—A trial distillation of Deodar wood containing 9·15 per cent. moisture was carried out in the small dry distillation still with the following results :—

	Per cent.
Pyroligneous acid	39·6
Tar	4·2
Tarry oil	14·9
Charcoal	30·3
Gases, etc., (by difference).	11·0

Deodar oil so obtained had Sp. Gr., 1·015 at 32°C. It contained 9·75 per cent. of moisture or total volatile matter lost at 110°C. On fractional distillation, in an ordinary distillation flask it gave the following fractions by weight :—

Up to 200°C	13·20
200°—220°C	9·47
220°—240°C	15·24
240°—260°C	18·08
260°—280°C	17·87
280°—300°C	6·96
300°—320°C	4·13
Pitch and residue (by difference)	15·05
TOTAL	100·00

Temperature rose to 320°C with difficulty.

The tar gave the following figures :—

	Per cent.
Sp. Gr., at 32°C	1·077
Moisture or volatile matter lost by heating it up to 130°C	40·64

Fractions by weight of the dry tar were :—

	Per cent.
Up to 200°C	14·73
200—220°C	16·68
220—240°C	19·19
240—260°C	13·30
260—280°C	15·27
280—300°C	6·73
300—340°C	4·40
Pitch and residue	9·70
TOTAL	100·00

The total tarry oil *i.e.*, mixture of the tar and oil obtained gave the following figures :—

	Per cent.
Sp. Gr. at 28°C	1·028
Moisture or volatile matter lost at 110°C	12·46

Fractions by weight of the dry oil were :—

	Per cent.
Up to 200°C	7·36
200—220°C	1·68
220—240°C	5·11
240—260°C	10·40
260—280°C	11·50
280—300°C	22·30
300—320°C	21·50
320—340°C	10·40
340—365°C	1·50
Pitch and residue	8·25
TOTAL	100·00

This work was taken up chiefly with the view of preparing tarry oil, which it was proposed by the Forest Economist should be tried as a wood preservative. This experiment was done in a very crude direct fire still. It will be seen that the tarry oil has 91·75 per cent passing up to 365°C and thus falls within the limits provisionally fixed for the antiseptic oils at this Institute.

But this oil can make a B. P. medicinallar and its uses as such are under inquiry.

The best season for collecting myrabolams as a tannin material.——This enquiry has been completed and a short note dealing with the results of the examination of myrabolams collection in different seasons has been published in the "Indian Forester" for January 1915. The results now obtained have confirmed the conclusion arrived at in the preliminary paper on the subject, also published in the "Indian Forester" 1911, Volume XXXVII, p. 509, that the fully ripe fruits are richest in tannin. As regards the season of collecting it, it has been shown that it would depend on the time of ripening of the fruits in different localities. Instead of allowing the myrabolams to remain as long as possible on the tree, as suggested in the preliminary note on the subject, it is recommended that they should be collected as soon as they are fully ripe.

Enquiry as to the possibility of reducing the harshness of tan barks.—This enquiry has been completed during the year. A paper suggesting the addition of fat to tannin extracts during the process of their manufacture was sent to the Secretary of the Society of Chemical Industry, London, with a view to its being read and discussed in one of the meetings. The Secretary sent it on to the Nottingham Section where it was read and discussed. Professor Proctor remarked that the idea given in the paper though not quite new seemed practical as they already add fat in the drum during the tanning process. This latter fact however was not known in India. Instead of adding fat in the drum, it has been suggested that it will be possible to reduce harshness of tannage of certain tannin extracts by the addition of fat when they are being evaporated in the vacuum pans. The experiments carried out on a Laboratory scale by the Chemical Adviser have yet to be confirmed on a large scale which will be done as soon as opportunity offers. If successful, it is likely that this slight modification in the process of tannin extracts manufacture will bring into use many tanning materials now almost useless on account of their property of tanning harsh.

The manufacture of products from *Boswellia serrata* and their chemical composition.—This investigation is near completion and a full report, it is hoped, will be ready by the end of the next year. Further experiments have shown that the only method which can produce all the three ingredients of this gum resin, uninjured and of good quality is the extraction of the material by means of a suitable solvent like benzine or "methylated ether." The contact of water whether in the form of water or of steam is injurious to the gum, while the resin obtained by steam distillation is

of too dark a colour for any commercial use. As a rosin size, it is useless as its saponification value is very low. A report from the Imperial Institute, London, received this year, says that it cannot be used even for dry distillation for the production of rosin oil. It is impossible to recover the gum by a steam distillation process. The only saleable product that can be thus obtained is the pinene oil described in the last year's Annual Report. The report on this oil received from the Imperial Institute, London confirms the results obtained in this Laboratory and shows this oil to be equal to the American and French turpentine oils with a difference of odour, which however is not unpleasant. The production of turpentine oil better in quality than Chir turpentine will be of great economic value in supplementing the supply of Chir turpentine oil. The samples of this oil are being sent to Calcutta firms with a view to secure its commercial recognition in India. Steam distillation being the least expensive method has been given a full trial but the results obtained are not satisfactory. The yield of oleoresin by fusing it out by steam in a specially designed still is about one quarter of the total quantity present. The remaining portion of the resin is irrecoverably lost in the emulsion of gum and impurities.

Conversion of "Sofia" into "Motia" Rosha Oil.—Though it has not been possible to devise any suitable method of concentrating the geraniol content of the "Sofia" oil and thus make it approach more nearly the "Motia" oil, still the change of the geraniol content of the oil into the corresponding aldehyde appears feasible. The samples of the "Sofia" oil so treated have yet to be sent for commercial valuation.

Indian Sumach (*Rhus Cotinus*),—In order to obtain an idea of the general percentage of tannin in the leaves and barks of *Rhus Cotinus* growing in different localities and to form some opinion as to the best season for its collection in India, samples of leaves and barks obtained from different localities and collected at different seasons of the year have been examined from time to time during the last two years. It has been found that the percentage of tannin (calculated on dry material) in the spring and summer samples of *Rhus Cotinus* leaves collected from different localities varies from 7 to 14 per cent. while the autumn samples were found to contain 21-26 per cent. In one case the tannin content had gone up to 31 per cent. The percentage of tannin was found to fall again in winter.

The percentage of tannin in *Rhus Cotinus* bark varies from 10 to 23 per cent. the summer and autumn samples being richer than the spring samples.

The percentage of tannin in *Rhus Cotinus* leaves is thus at par with the Sumachs of Europe and its extensive use has been recommended.

The best season for the collection of leaves of *Rhus Cotinus* in India is autumn, *i.e.*, after the rains, from the middle of September to the end of October, according to the locality and the time of the ripening and shedding of leaves. As in Europe, the leaves should be collected as soon as they are fully grown. The tan liquor, (calculated to contain 0·5 per cent. of tannin),

of a sample collected in spring gave with Loviband's tintometer, in one cm. cell, 3·1 red and 10·0 yellow; those collected in summer gave 1·5—4·3 red and 4·0—15·0 yellow; those collected in early autumn *viz.*, in September 3·5—4 red and 10·5—11·0 yellow, and those collected in November 5·6 red and 26·0 yellow. The winter sample also gave 5·6 red and 26·0 yellow. A Note on the Indian Sumach is under publication.

Bark of *Cassia auriculata.*—An interesting enquiry from the Superintendent of Forests, Marwar, regarding the exploitable age of *Cassia auriculata* with a view to obtain bark with the highest tannin content was dealt with during the year. A note on the subject has been published in the "Indian Forester" of January 1915. The mature bark gave more tannin than the young bark. There is no practical difference in the tannin content of the bark on coppice shoots of from 1 to 5 years old. Hence it is recommended that coppice shoots of from 1 to 5 years old be felled for their bark.

Of all the samples of *Cassia auriculata* bark examined the mature barks from Marwar are the richest in tannin, containing about 24 per cent. of tannin calculated on the dry material.

Zizyphus xylopyrus **fruits from Jhansi.**—A sample of fruit of *Zizyphus xylopyrus* received from the Divisional Forest Officer, Jhansi, was analysed to ascertain its tannin content. The moist pulp amounted to 62·20 per cent. and the stones to 37·80 per cent. It contained :—

Moisture per cent.	Soluble solids per cent.	Non-tannin per cent.	Tannin per cent.	Tannin on dry material per cent.
34·90	39·20	19·76	19·44	29·86

The fruit is thus fairly rich in tannin. A full inquiry as to the best season for its collection etc., is proposed and is in progress.

Use of Nickel Hydroxide in Tannin Estimation.—A further note on the use of Nickel Hydroxide in tannin estimation by the Chemical Adviser and his Assistant has been contributed to the Journal of the Society of Chemical Industry. In a previous note on the subject by the Chemical Adviser (published in Volume XXX, No. 15, pp. 936-937 of the Journal of the Society of Chemical Industry), it has been shown that freshly precipitated Nickel Hydroxide in the form of a thin paste serves as an excellent substitute for hide powder.

But a practical difficulty arose in the purification of freshly precipitated Nickel Hydroxide. It was very difficult to render Nickel Hydroxide prepared from Nickel sulphate absolutely free from sulphate. Moreover the word "a thin paste" did not convey any definite idea as to its consistency

and Nickel Hydroxide content. In the present inquiry, the Nickel Hydroxide in fine powder was substituted for the paste. Kaulbaum's "extra pure" Nickel Hydroxide powder which too contained traces of sulphate was repeatedly washed with hot water containing a trace of tannin acid. The Nickel Hydroxide powder thus purified was employed for tannin estimation. The comparative estimations of tannin in different tanning materials with hide powder and Nickel Hydroxide powder were tried with good results. The method finally proposed consisted in using about 20 gms. of water free Nickel Hydroxide powder for determination instead of hide powder, all other operations remaining the same as in the powder process. The advantage of this process is that Nickel Hydroxide unlike hide powder is a standard substance and is always available. A note on the subject has been sent to the Secretary of the Society of Chemical Industry, London, for discussion at one of the meetings of the Society.

Oleoresin of *Hardwickia pinnata*.—The oleoresin of *Hardwickia pinnata* was steam distilled and 34 per cent. by weight of oil was obtained. The oil was very thick and its specific gravity at 25°C was 0·9008, optical rotation in 100 mm. tube 8°18′. It gave the following fractions on being distilled in an ordinary flask.

	About 4 drops. Fractions by volume.
Up to 200°C	About 4 drops.
240°C	5 Per cent.
240—245°C	7 „
245—250°C	70 „
250—255°C	15 „
Above 255°C	3 „

It had no acid value. The iodine value (Hubl. 18 hours) was 232·67.

The constants of the oleoresin and the resin left behind after distillation are as follows :—

The preliminary composition of the *Hardwickia pinnata* oleoresin is :—

Oil per cent.	Resin per cent.	Moisture per cent. (by difference).
34·55	62·80	2·65

Its constants are :—

	Per cent.
Sp. Gr., at 24°C	1·019
Acid number	72·94
Saponification number	231·50
Ester number	158·56
Iodine (Hubl. 18 hours)	159·15

The resin which forms about 63 per cent. of the sample under reference gave the following constants :—

Sp. Gr.. at 23°C	1·098
Acid number	144·27
Saponification number	306·60
Ester number	162·33
Iodine value (Hubl. 18 hours)	88·01

The oil as reported by the Imperial Institute, London, cannot be substituted for copaiba oil. The enquiry as to the uses of the oil and the rosin has so far given negative results.

Camphor in dried camphor leaves.—A consignment of dried camphor leaves was received from Messrs. James Finlay & Co., Ltd., Ammayanyakanur, Madras, through the Forest Economist. The sample was steam distilled and the percentage of products obtained is tabulated below :—

Sample.	Moisture per cent.	Fresh camphor per cent.	Oil per cent.	Camphor calculated on dry material.	
				Fresh.	Dry.
(1) Dried leaves of camphor tree grown at Ammayanyakanur, Madras.	11·25	1·77	0·56	1·99	1·79

Camphor, content of a tree grown in Kaunli garden, Dehra Dun.—An entire camphor tree (*Cinnamonum Camphora*) was felled and its different parts were separately distilled with a view to finding out the variation in camphor and camphor oil content of the different parts of the tree. The girth of the tree at the base was 36½ inches and at the top of the trunk where it branched off was 32 inches.

The following parts were made into small chips and distilled separately. (1) Main stem, (2) Branches, (3) Thinner branches, (4) Twigs with green bark on up to 4½ inches in diameter and (5) Leaves with very short twigs.

The distillation was carried on at 20-25 lbs. pressure to start with and completed with 40 lbs. pressure. The separation of camphor from the oil

was satisfactorily effected in the camphor condenser designed by the Chemical Adviser. The results are as follows :—

No. of sample.	Loss at 100°C (mostly moisture per cent). in material as put in the still.	Camphor obtained from the condenser and pressed in filter paper per cent.	Oil per cent.	Fresh camphor calculated on the dry material per cent.	Oil on the dry material per cent.	Dry camphor calculated on the dry material per cent.
1. Stem . . .	43·11	0·66	0·49	1·16	0·86	0·97
2. Large branches .	21·27	0·46	0·34	0·58	0·43	0·51
3. Small branches .	29·43	0·21	0·11	0·29	0·15	0·25
4. Twigs with green bark.	27·72	0·27	0·19	0·37	0·26	0·31
5. Leaves with short twigs.	51·99	0·24	0·36	0·49	0·74	0·42

From these results, it is apparent that camphor wood grown in Dehra Dun is very poor in camphor as compared to Formosa wood which contains about 3-4 per cent of camphor.

The determination of moisture in fresh camphor.—The camphor in the condenser after being pressed between filter papers still contained some amount of water. The moisture was determined by two different methods. A weighed quantity of camphor was dissolved in petroleum ether and filtered after drying it on anhydrous sodium sulphate. The ether was distilled off, the last traces being removed by slow evaporation. The other method consisted in directly reading the volume of water in a stoppered graduated cylinder. A weighed quantity of camphor was placed in the cyl nder, petroleum ether was then added, which dissolved the camphor, the water settled down as an under layer and its volume was read off. The petroleum ether used was first shaken with water. A note on the subject has been published in the "Indian Forester."

Sandalwood from Vellore.—Six samples of sandalwood were sent by the Special Working Plans Officer, Southern Circle, Vellore, for the determination of the percentage of oil contained in them. It was observed that a naturally dead tree yields more heart wood than a living tree of the same age and girth, so it was thought fit to find out whether or not a tree girdled for some time before felling would yield more oil.

The samples were steam distilled and the percentage of oil in two samples of wood from two healthy and living trees growing at elevation of 1,560 feet and 3,200 feet was 5·03 per cent. and 3·11 per cent. respectively. A dying tree growing at 3,200 feet had 4·98 per cent. and a sample from a dead tree

at the same elevation had 2·82 per cent. The sample from a tree dead for five years had 3·81 per cent. whereas the sample from a healthy tree girdled before felling yielded 4·28 per cent.

From the above results, no definite conclusion could be formed as to the utility of girdling the trees before felling.

Sandalwood from South Canara.—Samples of the stem and the roots of a sandalwood tree were received from the Divisional Forest Officer, South Canara The stem had 8·82 per cent. and roots had 9·80 per cent. of oil. This is the richest sample of wood on record. The maximum percentage of oil in sandalwood recorded is 6 per cent. The tree was growing at an altitude of 500 feet on laterite in open forest. It was recommended that more samples from South Canara be examined in order to determine the average percentage of oil in the sandalwood of that locality, the samples examined appearing to be exceptional.

Antiseptic oil lost in the soil at Tanakpore.—In connection with experiments for the antiseptic treatment of sleepers at Tanakpore and Hardwar it has been found that a considerable quantity of the antiseptic oil is lost in the soil. It was therefore considered advisable to see if the oil thus lost could be recovered. The average percentage of oil absorbed by the soil was found to be 3·16 per cent. (determined by means of extraction with ether) and on destructively distilling a small quantity of soil, 1·82 per cent. of the total oil lost in soil was recovered. This indicates that probably 53 per cent. of the oil lost is recoverable.

Another sample of Tanakpore soil when extracted with ether was found to contain 9·68 per cent. of oil. On distilling a charge of 176 lbs. of soil, 54 per cent. of the total oil present in the soil was recovered. This recovery was in close agreement with the small scale experiments.

A sketch of a suitable plant for the recovery of the oil was also drawn up. The report was sent on to the Forest Economist for communication to the Conservator of Forests Kumaon Circle.

Oil lost in Hardwar soil.—The Hardwar soil impregnated with oil, was found to contain an average of 10·68 per cent. of oil. A charge of 288 lbs. was destructively distilled and 20 lbs. or about 67 per cent. of the oil present was recovered. The greater yield was due to the sandy nature of the soil which could be more uniformly heated. The oil obtained was found to fall within the specified limits for antiseptic oils. Its Sp. Gr., at 29°C was 1·098 and it had the following fractions by volume :—

Up to 200°C	Only 10 drops.
Up to 230°C	3·8 Per cent.
230—260°C	10·7 "
260—280°C	12·6 "
280—300°C	14·5 "
300—320°C	18·7 "
320—340°C	18·10 "
TOTAL FRACTION UP TO 340°C	78·4 "

Atropa Belladonna **from Kashmir.**—Five samples with leaves and roots of *Atropa Belladonna* were obtained from Kashmir. One sample of leaves received was badly injured in the transit by water and was rejected. They gave the following results :—

Description.	Moisture.	Ash soluble.	Ash Insoluble.	TOTAL ALKALOIDS
I. FROM GULMARG.	Per cent.	Per cent.	Per cent.	Per cent.
1. Total plant excluding roots . .	9·01	3·09	25·79	0·38
2. Leaves	14·44	6·63	7·84	0·45
3. Roots	13·34	4·42	6·51	0·14
4. Fruits	9·59	4·97	4·21	0·44
II. FROM MUZAFFARABAD.				
1. Leaves	..	..	..	.. Received rotten.
2. Roots	14·68	4·28	2·40	0·44

The alkaloidal content is lower than that of the leaves and roots of the British Belladonna.

Resin content of Chir shavings.—Three samples of shavings taken from (1) straight fibred and (2) and (3) twisted fibred chir timber were sent by the Forest Economist to find out if there is any variation in their resin content. No. 1 was found to contain 5·27 per cent. and No. 2 and 3, 0·54 per cent. and 0·51 per cent. respectively (all calculated on dry material). It seems the abnormal growth of the chir tree also retards the formation of oleoresin.

Tests of absorption of moisture in match splint impregnated with Ammonium Phosphate.—The North India Timber Ltd., Bareilly, United Provinces, wished to know the cause of the absorption of moisture by impregnated match splints and to find out if there is any remedy for it. The impregnating powder used by them was found to be Ammonium Phosphate. It is very hygroscopic. An air dry sample containing 9·28 per cent. of moisture absorbed 20·27 per cent more when exposed to aqueous vapour in a sealed bell jar for 17 days. Match splints containing 6·38 per cent. of moisture impregnated with 20 per cent. solution of Ammonium Phosphate absorbed 40·30 per cent. of moisture when similarly exposed. Match splints not impregnated with Ammonium Phosphate but coated with a thin solution of wax absorbed 18·35 per cent. Thus the cause of absorption of moisture was the impregnation with Ammonium Phosphate and also the porous nature of the wood ((*Bombax malabaricum*) used. The remedy recommended was a thick coating of shellac varnish (concentration 2½ lbs. in 1 gallon of methylated spirit) after impregnation.

List of Publications issued during the year or in Press at the end of the year.

GHOSE, T. P. & SINGH, PURAN. A Note on the use of Nickel Hydroxide in tannin estimation (*In Press*).

SINGH, PURAN . . A further Note on the best season for Collecting Myrabolams as tanning materials. (*Ind. For., January 1915*).

" . . . A further Note on Oil value of some Sandal woods from Madras. (*Ind. For., April 1915*).

" . . . A short Note on Camphor condensation (*Chemical Engineering and the Works Chemist, v, No. 51.*)

" . . . Note on the Indian Sumach, *Rhus Cotinus.* (*For. Bull., in Press*).

" . . . Note on the addition of fat to tannin extracts (*Journ. Soc. Chem. Industry, 15th March 1915*).

" . . . Note on Camphor Distillation (*Ind. For., xli No. 8*).

. . . . Note on *Cassia auriculata* (*Ind. For., January 1915*).

ASTRONOMY.

BY

G. C. SIMPSON, D.Sc., F.R.S.,

Officiating Director-General of Observatories.

Solar physics.—Researches in solar physics are carried on under the direct control of the Government of India at Kodaikanal, the Director being Mr. J. Evershed and the Assistant Director Mr. T. Royds. The chief instruments are :—

(*a*) A spectroheliograph made by the Cambridge Scientific Instrument Company, the object of which is to take photographs of the sun using the light emitted by one chemical element only. In this apparatus a stationary image of the sun is made by a 12-inch triple-achromatic lens of 20-foot focus, fed by an 18-inch Foucault siderostat. Close up to the image and somewhat longer than its diameter is the narrow vertical slit of a spectroscope arranged in such a manner that the light which has passed horizontally through the collimating lens shall be deflected through two right angles by two prisms and a mirror, and so shall emerge from the camera lens parallel to its original direction. This light then falls upon another vertical slit which can be adjusted in such a position as to allow light of any desired wave length to pass through. In the Kodaikanal spectroheliograph the collimating and camera lenses each of 5-inch aperture and 6-foot focal length, together with the prisms and slits, are attached to a rigid framework, while immediately in contact with the slit last described is a stationary photographic plate within a fixed camera. The rigid framework is capable of motion in a horizontal plane in such a manner that the primary slit may pass uniformly across the image of the sun while the secondary slit will move at an equal rate across the sensitised plate ; and as in each position an image will be formed at the second slit by light of the desired wave length and no other light can emerge, the result of the movement upon the plate is a complete image of the sun in monochromatic light. At present the H and K lines of calcium are largely used on account of the convenience afforded by the width of their absorption shading and the fact that the centre of the dark line is frequently 'reversed,' *i.e.*, is bright instead of dark indicating that the calcium vapour is abnormally hot in the higher levels of the solar envelope. A photograph so obtained shows

bright clouds—called 'flocculi'—of calcium vapour scattered about over the sun, and gives a large amount of information that is not otherwise obtainable. Further, by causing the slits to move more slowly the exposure may be lengthened sufficiently to give photographs of the 'prominences' projecting from the sun's margin.

(*b*) An autocollimating spectroheliograph built in the observatory workshop. This is attached to the side of the Cambridge instrument and shares in the very perfect transverse movement of the latter. It is designed for photographing the sun's disk in the hydrogen line C. A large grating is used to obtain the highly dispersed spectrum which is necessary in photographing with this line.

(*c*) A high dispersion spectrograph mounted on piers in the spectroheliograph room. This is fitted with special arrangements for rotating the sun's image on the slit plate, and for accurate guiding during long exposures on sunspots or prominences. A special device has also been added for photographing simultaneously the spectrum of an electric arc on either side of a solar spectrum. A grating by Rowland with 3¼-inch ruling is usually employed.

(*d*) An 18-inch parabolic mirror (the property of the Director) is mounted in the spectroheliograph room immediately in front of the 12-inch photo-visual lens. It is used to form the solar image on the slit plate of the high dispersion spectrograph. The mounting is on rollers and the mirror can either be moved into position in front of the lens with its centre in the axis of the beam of light coming from the heliostat, or it can be pushed to one side so as not to obstruct the light incident on the lens during employment of the spectroheliograph and associated instruments.

(*e*) An 8-inch visual achromatic lens from the Maharajah Takhtasinji Observatory, Poona, temporarily mounted in the spectroheliograph room on a pier near the Foucault siderostat. It is used for forming a solar image on the spectrograph slit specially for sunspot work.

(*f*) The polar siderostat has been converted into a horizontal telescope using either the 6-inch Grubb lens of 40 feet focus or the 8-inch lens from Poona in conjunction with a new grating spectrograph under construction.

(*g*) A 6-inch equatorial refractor with large grating spectroscope attached is used for the study of sunspot and prominence spectra and for recording the prominences by visual methods. The equatorial mounting and the spectroscope are from the Maharajah Takhtasinji Observatory, Poona.

Routine work.—In addition to the daily records obtained by the two spectroheliographs the routine work includes visual examination of sunspot and faculæ, sunspot spectra, and bright lines or displaced lines in spots and prominences. A monthly article describing the solar activity is contributed to the " Monthly Weather Review ", while for more technical purposes bulletins and memoirs of the Observatory are issued, of the former 46 have appeared and of the latter the first has been published.

Solar work in Kashmir.—It was mentioned in last year's report that the atmospheric conditions in Kashmir had been found extraordinarily favourable for solar work during the months of May, June and July. In order to determine whether these favourable conditions extend throughout the year the Government of India have provided funds for a well equipped expedition to spend nine months in Kashmir, and on July 15th, 1915, Mr. Evershed with a staff of observers and a large number of instruments arrived in Srinagar to undertake the work.

Spectroscopic Investigations.—The displacement of solar lines at points intermediate between the centre of the disc and limb have now been obtained by projecting a small image of the sun on the slit plate so that the slit passes along a diameter of the sun. When this is the polar diameter there is no displacement due to rotation and the wave-length of a solar line at any distance along the radius can be measured by comparison with atmospheric lines or with arc lines superposed on the sun's spectrum. When any other diameter is taken, the rotational effect is eliminated by taking points equidistant from the centre of the disc and making a small correction for their slight differences of latitude and longitude. In this way curves have been obtained showing the displacement at all points between the centre and limb. The form of the curves shows that pressure is not the cause of the displacements, as has already been deducted from the limb shifts in Kodaikanal Observatory Bulletins XXXIX and XLIV. A combination of an upward current and a surface current towards the centre of the disc, together with a constant displacement would account for the shape of the curves but the existence of these is improbable. The displacement curve resulting from a repellant earth effect is under consideration.

Displacements occurring in the arc owing to differences of density have proved themselves a convenient means for investigating the unsymmetrical character of spectrum lines. One result, that the character of the lines in certain series does not remain constant, nor consequently their pressure and density shift, has great practical and theoretical interest. This line of research is not being pursued further at present, however, but having been pointed out, it is hoped that it will be taken up in laboratories devoted to purely physical problems.

The displacement at the sun's limb of lines sensitive to pressure and desityn has been measured and found to be small relative to less sensitive lines ; the evidence is in favour of slightly lower pressure and density at the limb than at the centre of the disc.

It has been shown that the enhanced lines of iron partake in the descending movement at the centre of the sun's disc found in the case of the "arc" lines. There has therefore hitherto been found no evidence of ascending motion at the centre of the disc.

The following papers have been published since the last report :—

List of publications.

EVERSHED, J. . . . Summary of prominence observations for the first half of the year 1914. (*Bulletin No. xli*).

" " . . Report on the condition for Astronomical work in Kashmir. (*Bulletin No. xlii*).

" " . . Summary of prominence observations for the second half of the year 1914. (*Bullstin No. xlv*).

EVERSHED, J. & NARAYANA AIYAR, A. A. The displacements of the enhanced lines of iron at the centre of the disc. (*Bulletin No. xlvi*).

ROYDS, T. . . . The different character of spectrum lines belonging to the same series. (*Bulletin No. xliii*).

NARAYANA AIYAR, A. A. On the displacements at the sun's limbs of lines sensitive to pressure and density. (*Bulletin No. xliv*).

METEOROLOGY.

BY

G. C. SIMPSON, D.Sc., F.R.S.,

Officiating Director-General of Observatories.

Upper air investigations.—Until the beginning of July 1914, by which time the new observatory buildings in Agra were sufficiently near completion to be occupied, work was continued at the temporary quarters secured last year. The new buildings were occupied at the beginning of July and work was begun on their equipment. By the end of the year the internal arrangements were nearly ready for full activity; and work with instrument-carrying balloons at Agra and Poona, which was then on the point of being started, has been in operation during the monsoon months of 1915. Through the interest of the Mysore Government arrangements were also well forward for the starting of pilot balloon and cloud observations at their Central Observatory in Bangalore, and systematic work of this kind has since been carried on there.

Pilot balloons were sent up during the year at Agra and Simla, and cloud observations and measurements were made three times daily at several stations in India. In April 1914 a new pilot balloon station was sta ted at Kojak (Chaman), and special short series of balloon observations were made at Darjeeling from April to June and at Allahabad in May and June.

The major portion of the year 1914-15 was thus occupied with experimental work and preparations for its extension, but some progress was made in the analysis of balloon and cloud observations. The results in India of balloon flights were supplied to Dr. Filippi over the period covered by his similar work in the Himalayas; and a discussion of cloud observations made by the Survey Department in the Pamirs was contributed to their report of a journey in that region.

Statistical investigations.—With the object of correlating the chief meteorological phenomena and sunspots, all the available data of rainfall pressure and temperature have been gathered together from observatories having a long series of reliable records. The correlation coefficient between sunspots and each of these elements for each station has been calculated and the results shown by plotting the coefficients on maps of the world. The records from 153 observatories have been used for rainfall, from 98 for pressure and from 97 for temperature. Memoirs giving the results for rainfall and temperature have already been published and the memoir for pressure is in the press.

Wind Memoirs.—At the time of his death Sir John Eliot was engaged on writing a series of memoirs on the winds of India, based on the data accu-

mulated during a large number of years from Beckley anemometers. He had already discussed the records from eleven stations, and left the tabulated data for six other stations. These latter data have now been discussed by Mr. Harwood and the results published, so completing the work commenced by Sir John Eliot.

Storm warning in the Bay of Bengal.—During the period from 1st July to 30th October 1914, Mr. C. W. Peake was placed on deputation in the Simla office to investigate certain problems connected with locating the position of storms in the Bay of Bengal from the coast observations. A report on the work done and the conclusion reached is in course of preparation.

Publications.—The customary Daily Weather Reports of Simla, Calcutta, Bombay and Madras, the monthly and annual supplements to the Simla Daily Weather Report, the Monthly Weather Reviews, the Annual Summary, and various administrative pamphlets were issued during the year.

List of publications.

WALKER, GILBERT T. .	Monthly and annual normals of pressure temperature, relative humidity, vapour tension and cloud. (*Memoirs, xxii, Part iii.*)
,, ,, .	Correlation in seasonal variations of Weather, IV. Sunspots and Rainfall. (*Memoirs xxi, Part x*).
,, ,, .	Correlation in seasonal variations of Weather, V. Sunspots and Temperature. (*Memoirs, xxi, Part xi*).
HARWOOD, W. A. .	A discussion of the Anemographic observations recorded at Port Blair, Dhubri, Jubbulpore, Belgaum, Deesa and Karachi. (*Memoirs, xix, Parts iii to viii*).

TERRESTRIAL MAGNETISM.

BY

G. C. SIMPSON, D.Sc., F.R.S.,

Officiating Director-General of Observatories.

Magnetic observatories.—Bombay (Alibag).—The Bombay Observatory, formerly maintained by the Local Government at Colaba, was moved to Alibag in consequence of the introduction of electric trams into the city. It is now directly under the Government of India, the Director being Dr. N. A. F. Moos. The chief instruments are a set of magnetographs of the Watson pattern, a set of sight-reading instruments of Eschenhagen pattern, a Schulze earth-inductor, a Toepfer earth-inductor and ordinary magnetometers and dip-circles. There is also a large declinometer for eye observations, and the old Colaba horizontal force and vertical force magnetographs were in April 1912 transferred to Alibag for use as eye-reading instruments. There is thus a duplicate equipment both for absolute values and for variations.

The instruments have been in good order and under regular observation.

Dehra Dun, Kodaikanal, Barrackpore and Toungoo.—These observatories were started as base stations in connection with the Magnetic Survey of India, and are all equipped with Watson autographic instruments for declination, horizontal intensity and vertical force. Instead of dip-circles, earth-inductors of the Schulze pattern have been set up at each place. Good results have been obtained throughout the year.

The mean values of the magnetic elements for 1914 at the observatories are as follows :—

Observatory.	North Lat. and East Long.	Declination.	Horizontal force.	Vertical force.	North dip.
			C. G. S.	C. G. S	
Alibag . . .	18° 38′ 72° 52′	E 0° 44′ 15″	·36882	·16583	24° 10′·9
Debra Dun . .	30° 19′ 19″ 78° 3′ 19″	E 2° 18′·8	·33165	·32458	44° 22′·9
Barrackpore . .	22° 46′ 29″ 88° 21′ 39″	E 0° 32′·2	·37403	·22459	30° 58′·9
Kodaikanal . .	10° 13′ 50″ 77° 27′ 46″	W 1° 17′·1	·37571	·02750	4° 11′·2
Toungoo . . .	16° 55′ 45″ 96° 27′ 3″	E 0° 2′·6	·38983	·16628	23° 5′·1

Magnetic Survey.—Field Operations, 1914-15.—Two detachments, each under a Provincial Officer, were employed throughout the field season and a third detachment was sent out towards the end of the season for two months to assist in completing the season's programme which comprised observations to determine the values of the magnetic elements at 73 repeat stations in India and Burma, the inspection of three magnetic observatories and observations for the comparison of the instruments at each of the observatories.

At the recommendation of the committee appointed in 1914 by the Government of India, to discuss the position of the magnetic survey, the repeat stations were marked this season in a permanent manner by suitable concrete pillars and were handed over for preservation to the care of the local authorities so that there should be no doubt in future as to their exact position. These stations will henceforward be visited at intervals of 5 years for the accurate determination on the secular changes.

The officer in charge was employed during the field season with the assistance of the Head Quarters staff of the party, in carrying on the work of the final reduction of the field observations in Horizontal Force to the selected epoch and in the revision of the preliminary values of Declination from the additional data accumulated during the past few years.

The Magnetic Observatory at Barrackpore was closed on the 26th of April. This observatory was built in July 1903. Self-recording instruments showing the Declination and the intensity of the Horizontal Force were installed in August of the same year, and one for recording the Vertical Force in April 1907. These instruments have been in operation up to the 25th of April 1915.

The Committee which assembled in March 1914 to discuss the position of the Magnetic Survey and to advise as to its future programme came to the conclusion that the four observatories, at Dehra Dun, Alibag, Kodaikanal and Toungoo, were sufficient for recording the course of terrestrial magnetism in India, and recommended that the Barrackpore observatory should be closed as soon as a complete set of permanently marked field stations, scattered over the country, had been established and observations at all of them had been made. These observations at the 73 repeat stations alluded to above were finished at the end of April 1915 and the observatory has accordingly been closed, the buildings being made over to the Public Works Department.

Work during recess season, 1914-15.—The computation of the field observations during 1914-15 and the reduction and tabulation of the magnetic elements for the four survey base stations (Dehra Dun, Barrackpore, Kodaikanal and Toungoo) for 1914 have been completed; the mean values of these elements for the year 1914 derived from all days, excluding those of great disturbances, are given in the above table.

The reduction of the field observations in Horizontal Force and Declination to the selected epoch is in progress.

Programme for 1915-16.—During field season 1915-16 one detachment will take the field for about two months under the officer in charge to inspect the magnetic observatories and to take the usual observations for the comparison of instruments at the observatories. One or two repeat stations may also be visited if found to be necessary.

The whole strength of the Magnetic Party will be employed on the reduction of the Survey to the selected epoch.

GEOLOGY

BY

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CONTENTS.

MINERALOGY AND PETROLOGY.

1. **Hematite from Kajlidongri.**—Whilst on study leave at Cambridge, Dr. Fermor made a crystallographic investigation of two minerals collected some years ago at the Kajlidongri manganese mine, Jhabua State, Central

India. One of these was hematite in small crystals possessing the habit of corundum, the principal faces present being the basal plane (111) and the hexagonal pyramid of the second order $(6\bar{1}4)$. In addition to these the following forms were identified :—$(51\bar{3})$, $(71\bar{5})$, $(29.1.\overline{27})$*, $(51.1.\overline{49})$* ; $(10\bar{1})$, (100), $(22\bar{1})$, and (28.28.13)*—of which the three marked with an asterisk are new forms. Doubtful readings were also obtained for some 9 other pyramids and 7 other rhombohedra, the majority of which would be new forms.

2. **Hollandite from Kajlidongri.**—The other mineral investigated was hollandite, described, in 1906, as a new species having a composition corresponding to a salt of the acid $H_4 MnO_5$. The crystallographic study proves this mineral to belong to the pyramidal group of the tetragonal system, of which scheelite is the type. The crystals examined, which vary in length from $\frac{1}{8}$ inch to $1\frac{1}{2}$ inches, are tetragonal prisms of the first order (110), with the corners modified by the second order prism (100) and a series of hemihedrally developed ditetragonal prisms, of which the chief is (210). These prisms are terminated by a very flat pyramid taken as (111), modified in one case by the additional form (331). The accepted value of pp'' is 32° 9′, which gives the length of the vertical axis as 0.2880. If it be considered desirable to orient the mineral to show its relationship with scheelite, then the form (111) becomes (105) and the other faces suffer appropriate changes. The value of the vertical axis becomes 1.4400 compared with 1.5356 for scheelite, whilst the value of the angle pp'' for hollandite, which is 32° 9′, is seen to approximate to the angle dd'' of scheelite, which is 34° 9′, d being the form (105) in scheelite. The crystallographic relationship of these two minerals is significant in view of their chemical formulæ, which may be written as $R_2 MnO_5$ and $CaWO_4$ respectively.

3. **The origin of chondrules in meteorites.**—Whilst at Cambridge Dr. Fermor also made a detailed microscopic study of thin sections of the following Indian meteorites :—Bori, Donga Kohrod, Sindhri, Karkh, Bholghati, Chainpur, Mirzapur, Bilaspur (Baroti), and Khohar, his object being to study the characters of chondrules, in view of his hypothesis that they represent former garnets. The results of this work have not been entirely as expected and leave unsettled the question of whether the chondrules were once garnets or not. This is due to an unexpected feature which seems to be common to all the meteorites examined and to have escaped previous notice in the literature of the subject. This feature is so unexpected and, if accepted as true, carries with it such obvious difficulties that it is only mentioned with diffidence. Dr. Fermor states that had these thin sections been put before him as slices representing terrestrial ore deposits he would have had no hesitation in affirming that both the minerals, nickel-iron and troilite, had been formed later than the other constituents of the rock and had in many cases reached their present position by a process of metasomatic replacement. Each of these minerals, whilst also occurring with the silicates in the general ground-mass of chondritic meteorites, is often particularly abundant towards the periphery of, but

actually within, the chondrules. From a study of the structures of these meteorites it is concluded that many at least of these chondrules consolidated in their present position. There is no evidence to show whether the metallic minerals in the chondrules have been metasomatically introduced from without, or have been taken into solution from the material of the chondrules themselves and re-deposited in the peripheral portion. If the latter alternative could be upheld it would be possible to maintain the garnet hypothesis in an amended form, according to which, instead of supposing that the garnets suffered a dry fusion on release of pressure, water imprisoned in the rock gave the fusion an aqueo-igneous character so that certain constituents of a chondrule were temporarily taken into solution in water possibly above its critical temperature. One of the meteorites examined, Khohar, contains a great number of chondrules exhibiting polygonal outlines strongly suggestive of a mineral with the symmetry of garnet; whilst in another meteorite, Karkh, one slide showed an obscure patch of a colourless, isotropic, highly refracting mineral, strongly suggestive of garnet itself. Some ten other slides of this fall were cut without the discovery of any further patches of this mineral, so that it has not proved possible to confirm the determination. The presence of unchanged garnet in a chondritic meteorite would place an obvious difficulty in the way of accepting the garnet hypothesis of the origin of the chondrules. One certain point appears to arise from this investigation, namely, that although stony meteorites are not known to carry water, yet at some time in their past history water played an important part; and that changes have taken place within the meteorite since the formation of the chondrules is proved not only by the relationship of the meteoritic minerals to the silicates, but also by the cases, noticed in the Khohar meteorites, for example, in which intergrowth has taken place across the boundary of two chondrules in contact. Of the meteorites examined, all were chondritic except Bholghati and Bilaspur, and of these Bholghati proved to be a rather rare type, namely, a carbonaceous hypersthene-eucrite, analogous to the terrestrial norite; whilst the Bilaspur slide differed from Dr. Prior's description of the fall in being free from chondrules and not breccia-like. Of the chondritic meteorites Karkh contains abundance of an interstitial mineral that is possibly maskelynite, whilst Bori as well as the Bilaspur fall contain what is probably apatite, a mineral but rarely recorded from meteorites.

4. **The origin of calc-gneisses and crystalline limestones.**—The work now being carried out in the Central Provinces has raised once more the debatable question of the origin of the crystalline limestones, calciphyres and calc-gneisses of India. Professor Judd in 1896 advanced reasons for believing that the crystalline limestones of Upper Burma were chemically formed from pre-existing pyroxenic gneisses.[1]

5. Dr. Fermor, in 1903, when studying the manganese ore deposits of the Chhindwara district, Central Provinces, examined incidentally some of the

[1] *Phil. Trans. Roy. Soc.*, London, Vol. 187 A., p. 205.

numerous occurrences of calcareous rocks found in this region, and, in a paper published in 1906[1], advanced the hypothesis that the crystalline limestones of this area have resulted from the chemical alteration of pre-existing rocks containing an abundance of lime and magnesium silicates, and similar to or identical with the calc-gneisses (quartz-pyroxene-gneisses) with which the limestones are associated; the agent by which the alteration was effected being presumably CO_2 in solution. These calc-gneisses are a curious banded series of granulitic rocks constituted of some or all of the following minerals—diopside, hornblende, quartz, labradorite, microcline, epidote, garnet, sphene, zircon, ilmenite, and magnetite, and in special cases scapolite. In spite of the abundant felspar the obviously unusual chemical composition makes it difficult to regard them as formed from an igneous magma. For this reason Dr. Fermor in 1909[2] accepted these rocks as metamorphosed sediments, but still supposed that the crystalline limestones had been derived from the calc-gneisses, and suggested that the CO_2 which caused the change was a portion of that liberated during the conversion of the original impure calcareous sediments into calc-gneisses. The formation of the crystalline limestone was then supposed to be due to reversal of the reaction on alleviation of the pressure conditions. In 1908 Dr. A. W. G. Bleeck[3] in describing the occurrence of rubies in the Kachin hills, Upper Burma, showed that the accessory minerals in the crystalline limestones of that region were probably introduced as the result of the piezo-contact metamorphism of Weinschenk caused by intrusive granite. In 1913 Dr. Fermor during his geological survey of the Chhindwara district was able again to attack this problem in the field and mapped in the neighbourhood of Mohpani (21° 47′; 78° 57′) and Nautal (21° 47′; 78° 54′) a large number of irregular-patches of marble enveloped in ortho-gneiss and torn to shreds by intrusive granites and pegmatites. Where the contact with the enclosing gneisses could be observed thin shells of diopsidic granulite were observed, and this, taken in conjunction with the presence of the fluorine-bearing minerals chondrodite and phlogopite, was regarded as evidence of limited contact metamorphic action produced by the enclosing ortho-gneiss. Later in the same year in a paper read before the 12th International Geological Congress at Toronto[4] Dr. Fermor accepts as a more probable view that the calc-gneisses, calciphyres, and marbles, represent a banded series of calcareous sediments of various degrees of purity; but at the same time in order to explain numerous cases of replacement of gneisses by calcite he repeats his hypothesis that the CO_2 liberated during the formation of the calciphyres and gneisses may have re-attacked these rocks on release of pressure. In January 1913, W. L. Uglow, in "A review of the existing hypothesis on the origin of the secondary silicate zones at the contacts of intrusives with limestones[5]" initiated a valuable

[1] *Rec. Geol. Surv. India*, XXXIII, pp. 168-171.
[2] *Mem. Geol. Surv. India*, XXXVII, p. 299.
[3] *Rec. Geol. Surv. India*, XXXVI, pt. 3, p. 169.
[4] *C. R. de la XIIE Session*, Canada, p. 273.
[5] *Economic Geology*, VIII, p. 19-50.

discussion of the merits of the rival hypotheses to explain the formation of the silicate minerals in such metamorphosed calcareous rocks. According to one set of views the formation of these minerals is due to the re-crystallization of the impurities in the original sediments with later introduction of metallic and pneumatolytic constituents; according to the other, their presence in the metamorphosed rocks is due to the direct contribution from the invading magma not only of the metallic constituents, but also of the material required for the formation of the silicates.

6. Mr. Burton in his progress report for 1912-13 gives a full account of the metamorphic calcareous series as developed in the Seoni district. He regards the crystalline limestones as derived from sedimentary limestones of various degrees of purity, and accepts the formation of mica, pyroxene, amphiboles, and chondrodite, as due to the re-crystallisation of the original impurities in the limestone, with pneumatolytic addition of fluorine; but the felspar in the quartz-pyroxene gneisses he regards as in part of pneumatolytic origin. He thus favours in the main the re-crystallisation hypothesis. During the past season's work (1913-14) Mr. Burton had the opportunity of devoting further attention to these calcareous rocks as developed in the Balaghat district. This led to an interesting development of ideas, so that whilst Mr. Burton still supposes that the calc silicate minerals of the calc-gneisses (calc-granulites) were in part derived from original impurities in the calcareous sediments, he lays stress on the fact that the predominant felspar is microcline with varying amounts of orthoclase, plagioclase being present only in small amount or altogether absent. He deduces that this microcline was derived from the associated orthogneisses during folding, when the latter became refused and attained the condition of an igneous magma containing gases and pneumatolitic agents. The felspars both on the calc-gneiss and of the ortho-gneiss show quartz inclusions (*quartz de corrosion*), and this, Mr. Burton thinks, indicates that the calc-gneiss and the ortho-gneiss must have crystallised under the same conditions of pressure, indicating that the calc-gneisses are really mixed gneisses which have re-crystallised under plutonic conditions.[1]

7. **The origin of the kodurite series, Vizagapatam.**—In his account of the manganese-ore deposits of India[2] Dr. Fermor gives a list of the rocks intrusive into the rocks of the gondite series. These intrusive rocks are all varieties of granite, pegmatite, or felspar-rock, and many of them carry in addition one or more manganese-bearing minerals, amongst which may be enumerated spessartite-garnet, blanfordite, juddite, brown manganese-pyroxene, a yellow manganese-amphibole, braunite, and greenovite, the manganesian variety of sphene. Since these acid intrusive rocks carry manganese-bearing minerals only where they pierce manganese-ore or associated gonditic rocks,

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[1] During the present field season (1914-15) Dr. Fermor has accepted Mr. Burton's idea that these rocks are mixed gneisses and both he (in Chhindwara) and Mr. Burton (in Balaghat) have arrived at the conclusion that the hybridism has, at least in part, been effected by the *lit-par-lit* intrusion of the calcareous rocks by an acid magma. In Chhindwara, however, labradorite is as abundant as microcline in the calc-gneisses.

[2] *Mem. Geol. Surv. India*, XXXVII, p. 336.

it cannot be doubted that the manganese had been taken into solution from the invaded rock and incorporated in the intrusive whilst it was still in the molten condition. These manganesian acid rocks must, therefore, be regarded as hybrids. The highly manganesian composition of the kodurite series of Vizagapatam, described by Dr. Fermor as igneous intrusive masses, which, by differentiation have resolved themselves into whole series of rocks ranging from ultra-basic to ultra-acid, has always been a matter of surprise. For it has been difficult to understand how the ordinary processes of segregation within the Earth's crust could have led to the development of a magma so high in manganese as the kodurite series, which stands alone as a unique series amongst the rocks of the world as at present known. We have indeed, the remarkable case in India of two series of rocks, each rich in manganese, each characterised by an abundance of manganese-garnets, and yet one of them, the gondite series, undoubtedly a metamorphosed sedimentary series, and the other, the kodurite series, an intrusive igneous series. The relationship of these two series one to the other is unfortunately not at present known owing to our ignorance of the geology of certain tracts of country intervening between the regions where the two series are respectively developed. Dr. Fermor now suggests that the kodurite series may perchance be an example of hybridism on a large scale, in which, instead of a small pegmatitic or granitic intrusive having taken up a small portion of an ore-body, as in the manganesian pegmatites intruded into the manganese deposits of the Central Provinces, a granitic intrusive of some magnitude has bodily assimilated entire manganese-ore deposits. It does not follow that the constituents of the dissolved manganese-ore bodies became uniformly distributed throughout the magma ; each patch of koduritic rock as we now see it enshrouded in apatitic quartz-felspar-rock may represent the approximate locus of one fragment of the incorporated ore deposit, and the gradation from the ultra-basic garnet-rock in the centre, through basic kodurite, to acid kodurite at the periphery would then represent the results of the gradual diffusion of the dissolved body of manganese-ore into the granitic magma. The apatite so characteristic of the kodurite series would probably have been supplied by the invading magma. This idea can, of course, at present be regarded only as an interesting speculation needing for its confirmation the discovery in the kodurite country of older sedimentary manganese-ore deposits or manganese-silicate rocks. Such rocks have not yet been satisfactorily identified, but certain manganese-pyroxenites, which are closely associated with presumed metamorphosed sediments (khondalites and calc-gneisses) at Taduru and Chintelavalsa[1], and which Dr. Fermor was not able satisfactorily to connect with the kodurite series, may represent such sedimentary manganiferous layers modified perhaps by contact metamorphism.

8. Unfortunately very little analytical work has yet been carried out on the garnets of these two manganiferous series ; but such material as is available

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[1] *Mem. Geol. Surv. India,* XXXVII, pp. 21, 22.

indicates that the garnets characterising the gondite series must be regarded as varieties of spessartite with a low percentage of lime; whilst those characteristic of the kodurite series, for which the name spandite has been suggested, carry a relatively high percentage of lime. If there be any truth in the idea that the kodurite masses are to be regarded as a product of hybridism, then the high lime contents of the spandite will probably be due not to the solvent magma having been rich in lime, but to calcareous rocks having been picked up along with the manganese-ore body. Such rocks are seen in actual contact with the manganese-pyroxenites of Taduru and Chintelavalsa, and xenoliths of crystalline limestones are actually enclosed by the koduritic masses of the Kodur mine.

9. Associated with some of the gonditic ore bands of the Central Provinces we frequently find (especially where the country of the ore-body is ortho-gneiss instead of the more customary mica-schist or quartzite) a small amount of spessartite-bearing gneiss or of orthoclase or apatite-gondite. Such rocks are probably to be regarded as hybrids between the manganiferous sediment and the enclosing ortho-gneiss, and it is to be noted that apatite-orthoclase-gondite is closely comparable with quartz-kodurite, each rock carrying quartz, orthoclase, and apatite, but with different varieties of manganese-garnets. No analysis has yet been made of the manganese-garnets in the pegmatitic intrusives into the gondite series, but in habit and colour they are indistinguishable from the manganese-garnets in the gondite rocks and thus are probably spessartite. In his progress report for 1913-14 Mr. Burton attaches the name quartz-kodurite-pegmatite to a rock from the Netra mine, Balaghat district, but this term will only be strictly applicable if the garnet be high in lime.

10. If future investigation should support this idea that the kodurite rocks are really hybrids, it will introduce a pleasing homogeneity into the whole question. It will also suggest the possibility of correlating a portion of the manganiferous rocks and associated sediments of the Central Provinces with the manganese-pyroxenite of Taduru and Chintelavalsa and their associated sediments which are khondalites and calc-gneisses. Mr. Burton has already suggested the correlation of the calc-gneisses of the two regions on the basis of the associated sillimanitic rocks found both in Balaghat in the Central Provinces and in the Vizagapatam district.

11. **Microchemistry.**—While on study leave in Europe this summer Dr. W. A. K. Christie besides making a study of the assaying methods in use at the Royal Mint, London, was engaged chiefly in micro-chemical work during the summer session in the laboratory of Professor F. Emich at the Technische Hochschule of Graz, Austria, and during the autumn in that of Professor N. Schoorl at the University of Utrecht, Holland.

12. At Graz the quantitative methods worked out by F. Emich and J. Donau were studied in detail. The chief difficulties hitherto encountered in India in quantitative microchemical analysis have been the making and

repair of the delicate apparatus required, more particularly in connection with the Nernst-Emich microbalances of quartz fibre and the Donau platinum filters. The technique of manufacture and manipulation having been acquired attention was chiefly directed to such determinations as would be most useful from a mineralogical point of view, and latterly to new methods for the micro-analysis of silicates, a subject on which, up till then no work had been done. The results obtained were distinctly encouraging.

13. In Utrecht a study was made of the microchemical reactions and separations already worked out with systematic completeness by Professor Schoorl, and advantage was taken of the latter's wide experience in applying the methods to the analysis of complicated ores and rock-forming minerals.

14. The application of microchemical methods and particularly of quantitative ones, has hitherto been greatly neglected in geological work not only in India and a knowledge of them cannot fail to be of service in many instances where only minute quantities of material are available for investigation.

PALÆONTOLOGY.

15. **Tertiary Mammalia : Siwalik Primates.**—Dr. G. E. Pilgrim acted as Palæontologist throughout the year. He was engaged in the revision of the Siwalik *Primates*, including both the specimens on which the species *Dryopithecus punjabicus* Pilg., *Sivapithecus inducus* Pilg. and *Semnopithecus asnoti* Pilg. were originally founded but with no more than a brief preliminary notice, as well as additional material obtained since 1910.

16. The results of his examination are contained in a paper published in part 1 vol. XLV of the Rec. Geolog. Survey of India. A maxilla and upper teeth of the species *Dryopithecus punjabicus* have been described, and two new species of *Dryopithecus* established. A new genus, *Palaeosimia*, which Dr. Pilgrim considers ancestral to the Orang, has been described and the species *Semnopithecus asnoti* has provisionally been assigned to the African genus *Cercopithecus*. Several additional lower teeth and portions of the mandible of *Sivapithecus* have been discovered, which, in the author's opinion display a decidedly human affinity. These, occurring as they do in a miocene species, point to their owner being an early member of the *Hominidæ*.

17. **Indarctos and Dissopalis.**—Dr. Pilgrim has also written papers, published in the last volume of these *Records*, descriptive of a new genus of bear, *Indarctos* from the Middle Siwaliks, and of a new creodont genus, *Dissopsalis*, from the Lower Siwaliks. The latter represents a curious survival in India of a type, which had become extinct elsewhere, its nearest relatives being found in Eocene genera of Europe and North America.

18. **Sivælurus and Paramachærodus.**—The present part contains a paper by Dr. Pilgrim on two new genera of cats from the Lower and Middle Siwaliks, *Sivælurus* and *Paramachærodus*. These are allied to species from Pikermi and Maragha and seem to afford evidence of a special line of development not hitherto recognized.

19. **Middle Eocene Mammalia of Burma.**—Mr. G. de P. Cotter towards the end of the year announced the discovery in Burma of mammalian remains in beds which he believes to correspond to the Pondaung Sandstone and to be of Upper Eocene age. If this proves correct these are the earliest reported land mammalia in Asia.

20. **Upper Siwalik bone bed near Kalka.**—Mr. Hallowes was deputed during last July to examine a bone deposit which was reported to occur in the neighbourhood of Kalka. Mr. Hallowes located it near Baddi, some 15 miles north-west of Kalka. The locality is known to Dr. Pilgrim, who assigns the beds to the Pinjor zone of the Upper Siwaliks. Mr. Hallowes brought back a collection of mammalian remains, of which the most interesting are some teeth and vertebræ of *Sivatherium* and a tooth of *Equus*. The latter genus has not previously been recorded from this horizon, and Dr. Pilgrim suggests that its occurrence here may make it necessary to shift these beds to a somewhat later position in the geological scale than had hitherto been suspected.

21. **Tertiary Mollusca of North-West India.**—Mr. E. W. Vredenburg is still engaged on his description of the Oligocene and Miocene mollusca of North-West India which, however, is now approaching completion.

22. **Palæontological work in Europe : Spiti Shales fossils.**—Amongst the fossils of the Spiti Shales, which were in the late Professor Uhlig's hands, were a few ammonites left undescribed by that author as well as the whole of the *Brachiopoda*. A memoir on these has now been published by Miss Paula Steiger of Vienna as fascicle 5 of the Fauna of the Spiti Shales, *Pal. Indica*, series XV, Vol. IV. With the collection of the Geological Survey of India she has included in her examination certain specimens collected by the Brothers Schlagintweit and now in the Palœontological Museum of Munich. The ammonites belong to the genus *Perisphinctes*. Amongst them are 11 new species, of which 6 are referred to the subgenus *Aulacosphinctes* and 2 to the subgenus *Virgatosphinctes*. Some of these are, however, rather fragmentary. The *Brachiopoda* are poorly preserved, and Miss Steiger has referred them to the groups of *Rhynchonella lacunosa* Quenst., *Rhynchonella trilobata* Zeiten. and *Rhynchonella Asteriana* D'Orb., merely suggesting their respective affinities, but without venturing actually to identify them with previously known species. The results of her examination are in entire agreement with those obtained by Uhlig.

23. **Ordovician and Silurian of Northern Shan States.**—Mr. F. R. Cowper Reed has completed a supplementary memoir on new Ordovician and Silurian fossils collected in the Northern Shan States by Messrs T. D. LaTouche, J. Coggin Brown and others in the year 1904—07. This will be published very shortly.

24. The species described not only augment the lists published in the author's previous memoir of 1906 to the extent of rather more than 100 species, including one new lamellibranch genus, *Shanina*, and 39 species which are

new to science, but also provide evidence of a more complete stratigraphical sequence than was at first recognised. A more satisfactory correlation has been rendered possible by the discovery of well-known European zone graptolites, and of other fossils showing affinites to species of known geological horizons.

25. As Mr. LaTouche had the advantage of Mr. Cowper Reed's provisional determinations, the majority of the latter's stratigraphical results have been embodied in his memoir on the Geology of the Northern Shan States published in *Mem. Geol. Surv. Ind.*, Vol. XXXIX, pt. 2 (1913).

26. The faunal affinities of the Upper as well as of the Lower Naungkangyi beds are clearly shown to lie with the Ordovician of northern Europe and not with that of America. The whole facies of this fauna is different, both from that of the Central Himalaya of Tonkin and of Sze-chuan in China, but shows certain resemblances to that collected by Mr. Coggin Brown in Western Yünnan. Mr. Cowper Reed refers the Naungkangyis, both in their upper as well as in their lower portions to the lower Ordovician. The fossils of the Hwe Maung or Upper Naungkangyi beds of the eastern area indicate a slightly different age to those of the western area, but the palœontological evidence is insufficient to decide which of the two is the older. The Panghsa pye beds are shown to be of Lower Llandovery age, and have equally a European stamp in which they agree with beds of a similar age from the Central Himalayas.

27. **Ordovician and Silurian of West Yunnan.**—Mr. Cowper Reed has also completed his description of the fossils collected by Mr. J. Coggin Brown from the Ordovician and Silurian beds of Western Yünnan. This will be published within the next few months. The results of Mr. Cowper Reed's provisional determinations have already been made known in these *Records* in a short paper by Mr. J. Coggin Brown, *Records Geol. Surv. India*, XLIII p. 327. Some 70 species are described in addition to 25 species of graptolites identified by Miss Elles with previously known forms. Of these, 20 are new to science, including two new cystidean genera, *Sinocystis* and *Ovocystis*. The Ordovician fauna may be assigned to the lower portion of that system, though probably occurring at four or five slightly different horizons. Like that of the Northern Shan States, its affinities are with the North European rather than with the American type, and present an altogether different facies from the Ordovician fauna of Eastern Yünnan and Tonkin described by MM. Mansuy and Deprat. His failure for the most part to recognize any species, which are actually identical with those of the Naungkangyi beds, inclines Mr. Cowper Reed to place them, however, on a slightly different horizon. The fauna which most resembles that of the Northern Shan States is that found at Shihtien, which recalls that of Sedaw.

28. The Silurian is represented only by the graptolites from Shihtien, which Miss Elles regards as of Llandovery age, though of two horizons not far apart from one another, of which the higher belongs to the base of the zone of *Monograptus sedgewicki*.

29. **Namyau Brachiopoda of Northern Shan States.**—A large memoir on the Namyau Brachiopoda of the Northern Shan States by Mr. S. S. Buckman is drawing near to completion. A preliminary notice of this memoir and a brief summary of its contents were published in part 1 of the present volume of these *Records*. Its most striking feature seems to be a proposed new classification of the genera *Rhynchonella* and *Terebratula*, based on the internal characters as displayed by burning off the test. The original genus *Rhynchonella* is sub-divided into 44 genera, and *Terebratula* into 32. The Burmese species of *Rhynchonella* are about 40 in number and have for the most part been referred to the new genus *Burmirhynchia*, while the Terebratulids amount to some 20 species belonging to the genus *Holcothyris*. Mr. Buckman considers that the beds are of Bathian age about the date of the great Oolite.

30. **Fauna of the Gieumal Sandstone, etc., of Spiti.**—Dr. A. Spitz's description of the fossils from the Gieumal Sandstone has been translated by Mr. Vredenburg and published in Vol. XLIV, part 3 of the *Records*. The specimens described were originally collected by Stoliczka, Griesbach, Krafft, and Hayden. They include principally bivalves (mostly *Cardium* and *Pseudomonotis*), mostly peculiar to this formation, and a few incomplete ammonites (*Astieria*, *Parahoplites* and *Stoliczkaia*). The fauna is too localised to allow a very definite determination of the age of the beds which may range from Upper Neocomian to Gault.

31. Dr. Spitz has also described and figured the foraminifera from the overlying Chikkim Limestone of Spiti, including *Nodosaria*, *Cristellaria*, and *Textularia*, none of which, however, are of definite stratigraphical value.

32. The paper finally contains a description of some fossils from Griesbach's so-called Chikkim Limestone of Hundes (Mem. XXIII, p. 80) including *Cucullæa*, *Astarte*, and a belemnite related to *B. Gerardi*, which are evidently not of Upper Cretaceous age (the probable age of the genuine Chikkim limestone), and may indicate the presence of an *exotic block* of Upper Jurassic or Lower Neocomian age.

33. **Upper Ranikot lamellibranchs of Western Sind.**—Messrs. Cossmann and Pissarro's description of the lamellibranchs from the Upper Ranikot of Western Sind, is being translated by Mr. E. W. Vredenburg. When ready, it will be published in the *Palæontologia Indica*, and will complete the molluscan fauna of the Lower Eocene of Sind of which the *Gastropoda* were published in Vol. III, part 1 of the *Palæontologia Indica* (New Series).

34. As might be expected from the generally wider geographical distribution of bivalve molluscs as compared with gastropods, the Ranikot lamellibranchs do not represent quite so isolated a fauna as the previously described gastropods. In addition to certain forms either previously described by d'Archiac and Haime or newly established by Messrs. Cossmann and Pissarro, that are peculiar to Sind, several species previously known from the Eocene of Egypt or Europe have also been recognised, such as *Ostrea multicosatta* Desh., and *O. Pharaonum* Oppenheim.

35. **Echinoids of the Bagh beds.**—A revision of Dr. P. M. Duncan's types of the echinoids of the Bagh beds by M. Fourtau has been received and at present is in process of translation from the original French by Mr. G. H. Tipper.

36. **Cretaceous and Eocene of Central Tibet.**—A description of Dr. H. H. Hayden's collection of Cretaceous and Eocene fossils from Central Tibet by M. Henri Douvillé has also been received. As the translation of this, also by Mr. Tipper, is still in progress, the review of the contents is postponed till the next Report.

ECONOMIC ENQUIRIES.

Bauxite.

37. **Central India and Central Provinces.**—In 1913, at the conclusion of his work in Korea State, Dr. Fermor visited Amarkantak (3,500 feet), forming the culminating eastern peak of the main Satpura range, in order to ascertain whether this great height was due to a greater thickness of the Deccan Trap than usual or to the existence of a pre-Trap peak of crystalline rocks. On the way up the Ghat he found that the surface of the gneiss rose to a height increasing from 2,570 to 2,660 feet, the lower portion being overlapped by a hundred feet of Talchir-like rocks. Resting on the Talchirs, "Lameta" limestone was found through an elevation of 90 feet, this excessive thickness indicating perhaps a continued rise of the underlying gneissic surface. This limestone was succeeded by about 670 feet of Deccan Trap lavas, capped by laterite. This was seen through a difference of elevation of 140 feet; but as the laterite was obviously covering a rising surface of trap its actual thickness was much less than this figure, probably not more than 65—70 feet. Amongst the detritus obscuring the exposures on the Ghat road was a great abundance of fallen laterite blocks, many of which consisted of bauxite, often pisolitic and apparently of the best quality. On the plateau of Amarkantak a considerable quantity of bauxite of variable quality was noticed, and even the numerous temples congregated round the source of the sacred Narbada river were mostly constructed of this material. There is a considerable area of ground covered by laterite in this neighbourhood, both in Rewah State and in the Mandla and Bilaspur districts, Central Provinces; and should a careful examination of these hills lead to the discovery of bauxite deposits of any size they might prove to be of economic value; for although the locality is somewhat remote, yet a good site for water power is close at hand.

38. In 1912 Sub-Assistant M. Vinayak Rao discovered bauxite of good quality, on the Amagarh scarp seven miles south-east of Seoni town in the Seoni district; this he further investigated the following year. No excavations have been made, but blocks of bauxite were traced for about two miles

and a representative block examined in the Geological Survey laboratory gave the following results on analysis :—

SiO_2	1·36
TiO_2	12·08
Al_2O_3	54·78
Fe_2O_3	3·17
H_2O	28·25
	99·64

39. In 1913 Mr. R. C. Burton, working to the south of Amagarh, discovered blocks of bauxite in ferruginous laterite at many localities, *e.g.*, Senduria, Amutpani, Patrai, and west of Salai. Near Atarwani, still further to the south in the same district, Mr. Burton found a small hill containing a deposit of bauxite estimated to be twenty feet thick, and lying between beds of ferruginous laterite. Blocks of 70—80 cubic feet in volume lie on the hill sides, but the area covered by the outcrop is small. The quality was apparently good.

Coal.

40. **Wetwin : Northern Shan States.**—At the instance of the Government of Burma, Mr. J. Coggin Brown during December examined the coaly material of Wetwin, 9 miles (as the crow flies) east of the Lashio branch of the Burma Railways at Wetwin station.

41. Mr. Brown was unable to determine whether the coal seams were comparable with those carbonaceous shales which are interbedded with the limestones belonging to the Plateau limestone (Devonian) of LaTouche (see *Geology* of the Northern Shan States, *Mem. Geol. Surv. of India*, Vol. XXXIX, pt. 2, p. 255) or to the Tertiary strata of the Shan States and Upper Burma, to which latter it has a remarkable resemblance. The high dip of the strata is, however, against the latter interpretation, if the Shan States only be considered, although in Southern Yünnan, according to the Indo-China geologists, exactly similar deposits often exhibit a steep dip.

42. Three outcrops are described, all lying as Mr. Brown thinks at about the same horizon. The coal is a dull black colour, resembling carbonaceous shale. On exposure to the air it quickly crumbles to powder. Three carefully sampled lots of the material have been assayed in the laboratory of the Geological Survey with the following results :—

Sample number.	Moisture.	Volatile Matter.	Fixed Carbon.	Ash.	Colour of Ash.	REMARK.
1	17·44	37·84	33·56	11·6	Brown .	Does not cake.
2	16·94	39·19	34·43	9·44	Do. .	Do.
3	14·80	38·10	32·78	14·32	Buff .	Do.

In considering these analyses it is necessary to remember that they were all performed on exposed and weathered material, but taken as a whole, they all show a high percentage of moisture and ash, and that preponderance of volatile matter over fixed carbon which is usually associated with the lignites or brown coals of Tertiary age.

43. No estimates have been made of the total quantity of the coal available, as this could not have been done without extensive operations and possibly borings. Apparently the coal has not been successful as a boiler fuel, and all the objections brought forward by LaTouche and Simpson to the Shan States coal (*Rec. Geol. Surv. of India.*, Vol. XXXIII, pt. 2, pp. 117, 125) apply with equal force to this Wetwin material, and in addition there is the long lead to the railway over bad country. For these reasons, and because briquetting would be necessary, Mr. Brown thinks that the coal possesses very little economic interest at the present time.

44. **Western India : proposed borings.**—The speculative question of the existence of incropping coal measures in Western India beneath the covering of Deccan Trap (on the analogy of those beneath more recent formations in Kent and Northern France) dates back to enquiries put before this department in 1907. The matter came definitely to a head in June of the year under report by the forwarding to this department, by the Agent to the Great Indian Peninsula Railway, of certain correspondence with the Board, wherein Mr. F. L. G. Simpson, Manager of the Mohpani Colliery, put forward the specific localities of Kalyan, Bhusaval and Khandwa, as those at which he considered the overlying Deccan Trap might be thinner than elsewhere, and so be suitable for experimental borings in the hope of reaching coal at no greater depth than 250 feet.

45. The subject, in spite of its discouragingly problematical character, was referred to Mr. C. S. Fox, who was more familiar with the geological conditions of this area than any one else in India at the time. His investigation of the geological literature of the subject indicated :—(1) that the deposition of the Gondwana coal-bearing rocks began in a series of isolated depressions, roughly arranged in definite lines ; (2) that a partly water-worn mountain chain stretched in an easterly direction across the Peninsula, corresponding with the present position of the Satpura range and its eastern extension ; and (3) that this mountain chain had been breached in at least three places from north to south. The Narbada-Son-Himalaya group of basins lay to the north of the old mountain chain, the basins of the Damodar, the Mahanadi and the Wardha-Godavari rivers crossed eastwards and south-eastwards through the breaks in the chain. The coal-fields were found at the time when the basins had probably become connected by large sluggish rivers winding their way outwards, west, east and south-east, from the high ground of the uplands over modern Mandla. Not till very latest Gondwana times, however, had the streams a continuous flow, connecting the central regions with the sea. The old basins were probably fault rifts, and at a later date when the volcanic eruptions of the Deccan Trap arrived, further movements along the fault

planes appear to have taken place, in some cases preserving whole coal-fields within the limits of their original deposition.

46. The possibility of the existence of coal under the trap of the Bombay Presidency depends upon the existence of another line of Gondwana basins under the traps. This seems a possibility in view of H. B. Medlicott's opinion that the Satpura basins almost certainly had an outlet to the west.

47. After considering the altitude and situation of various localities proposed for borings, Mr. Fox's conclusions, with which I am in agreement, are summarised in the final praragraph of the note put up by him, in which he writes :—" It will, I think, be a waste of time and money to sanction borings that are to be restricted to a depth of 250 feet. If the intention is to exploit the area in a purely experimental manner, then two borings of 1,000 feet each should be put down, one at Bhusawal or Dhulia and the other at Kalyan. In each case the whole operations must be treated in the spirit of sheer pioneer work. If a timid boring of 250 feet is all that can be considered, I have little hesitation in saying that it is not likely to get through the traps, and very little information for future guidance will have been obtained ; whereas, a boring carried through the trap, even if it does not hit a coal seam at once, will give information that should definitely settle the prospects of finding coal under the trap of Western India."

48. It is to be hoped that this critical opinion of the proposals will not deter, but rather stimulate, the Board to sanction the deeper borings (proper care being taken of the cores brought up) for it cannot be denied that as regards Western India such trials will have to be made sooner or later in the interests of water, coal or both.

Limestone.

49. **Upper Assam.**—The demand for limestone for certain parts of Upper Assam has long been a pressing one, owing to the scarcity there of such deposits. Numerous enquiries from time to time have been received by this department from the Assam Government, the Railway authorities and private firms regarding suitable stone for agricultural and building purposes and one more readily accessible than that of the celebrated but distant, Sylhet quarries.

50. The majority of these enquiries centered round the locality of the Mikir Hills, where Nummilitic limestone of the same formation as the Sylhet stone, has long been known. Finally this department was definitely asked by the Assam Government to depute an officer to make a detailed examination of the deposits of these hills, with the particular object of selecting a locality where a limestone industry would have the greatest prospects of success, and be favourably situated as regards the railway. At the end of October, I was able to depute Sub-Assistant M. Vinayak Rao for this purpose before taking up his regular cold weather work. Notwithstanding the adverse climatic and other conditions he succeeded in selecting three localities in the Disboi Jan,

Meyongdisa and between Borojan and Deopani, where a suitable quality and amount of the limestone could be best obtained.

Manganese.

51. **Central Provinces.**—In the course of his work in western Balaghat, Central Provinces, Mr. Burton visited several manganese quarries and collected notes about five deposits not described by Dr. Fermor in his memoir on the subject, namely, Gola Hurki, Netra, Biahtekor, Bukoda, and Chibarghat nala, north-west of Budbuda, of which the last three had been abandoned owing to the poor quality of the ore. The ore bed at Gola Hurki and Netra is 15 ft. and 16 ft. thick respectively and carries a fair quantity of ore of good quality. A pegmatite at Gola Hurki contains well developed crystals of braunite, up to 2 inches in diameter, and often twinned.

Potassium Salts.

52. In July Dr. W. A. K. Christie, in the company of the Chief Inspector of Mines in India and the Assistant Commissioner, Northern India Salt Revenue Department, Khewra, visited the Prussian potash mines at Stassfurt to study the mineralogy of the deposits and the methods of mining employed, with a view to utilising the knowledge gained in connection with the possible development of the potash deposits at Khewra and Nurpur in the Punjab Salt Range, the investigation of which formed the subject of a report already published in the *Records* in the year under review. The Prussian deposits differ markedly from those found in India. They are, of course, incomparably greater in extent, but mineralogically there is also a wide difference ; although both were probably similar at the time of their deposition, the Punjab deposits have been affected to a much greater extent by thermal metamorphism, so that carnallite, for instance, one of the chief products mined at Stassfurt, is unknown in India.

53. Since the outbreak of war the subject has assumed an added importance, for the main sources of the world's supply—the deposits in Germany and Austria—have been cut off. Although no real potash famine has supervened, chiefly owing to the reopening of many neglected sources in Europe and America, the possibility of the economical exploitation of the Indian deposits has been enhanced, and the subject is now engaging the attention of the Government of India.

Road Metal.

54. **For Calcutta.**—In July 1914 the Chairman of the Calcutta Corporation, after some correspondence on the subject, asked for the services of an officer of this department to inspect certain localities within a reasonable distance of Calcutta, with a view to selecting quarries that would yield a suitable stone for road metal for the Calcutta streets. The Corporation required about 20 lakhs of cubic feet per annum of stone for at least 20 years for this

purpose, or in other words 40,000,000 cubic feet altogether ; and, for reasons connected with efficient breaking and screening, desired to acquire or lease a quarry in preference to the old method of giving out contracts from year to year for supplying the stone.

55. Dr. Murray Stuart, who had recently returned from deputation to Madras, was opportunely available, and was instructed to comply with this demand. During the latter part of August he inspected 12 localities from which offers of leases had been made, and he eventually selected the hill of Deccan Trap called Malphari near Pakur in the Sonthal Parganahs, as being the most suitable, because it would allow a quarry to be excavated with a face of rock at which to work. Mention was also made in his report of other less desirable localities, where it was probable that a large supply of boulders could be obtained, with the likelihood of solid rock being found a short distance below the surface, though there was no proof of this and water troubles would be sure to occur in the rainy season.

Water.

56. **Berar, Central Provinces.**—Early in the cold weather season of 1912-13 enquiries were made of this department by the Sanitary Engineer to the Central Provinces Government regarding the probabilities of obtaining a supply of water from tube wells sunk in Berar and Nimar districts of the Central Provinces, where existing wells were shallow, and rock encountered comparatively near the surface. In particular, our opinion was asked if there was a reasonable chance of success if some trial borings were made with two or three hand-power diamond drills suitable for boring to a depth of about 250 feet. This began a correspondence which, early in the summer of 1914 resulted in my deputing Mr. C. S. Fox, who was geologically surveying the neighbouring districts of the Central Provinces, to visit the area at the close of his field season. Mr. Fox accordingly spent the latter part of April till the middle of May examining the water-supply conditions in what is known as the " Saline Tract " and neighbouring parts of Akola district, Berar. A very full examination was made, and a detailed report sent in early in August. Mr. Fox's results and conclusions tended to shatter the hope that deeper wells in the alluvium would be likely to yield sweet water, or that still deeper wells piercing down into the trap rock would, as a matter of course, yield water under artesian or semi-artesian conditions. The procedure which he suggested was to utilise and systematise the present fresh water supplies as far as possible, supplementing them if necessary, from other sources drawn from the better watered northern tracts, and distributing the whole throughout the saline tract by pump and pipe.

57. **Bombay.**—During the year reviewed a fresh impetus has been given to the study of water questions in the Bombay Presidency. This subject, which for many years in the past had been under consideration from time to time, came prominently forward in July 1912, when the Hubli municipality

purchased a boring plant and proposed sinking to a depth of 1,000 feet. Since then, in consequence of the activity of the Agricultural and Sanitary departments in the matter of well-boring operations for water in different parts of the Presidency, the Bombay Government in October of 1914 appointed a committee to examine the results already attained, with the object of laying down a policy to be pursued in the future; and they asked this department for the services of Mr. A. M. Heron (who is deputed annually to the Engineering College, Poona, for lecturing on geology) to advise the Committee on any points on which they may require his assistance.

58. As Mr. Heron was then in camp, carrying on his ordinary cold weather geological duties in Rajputana, he was only able to do so by correspondence. Mr. Heron, after referring to the known capabilities of the alluvium and Tertiary beds of Sind and Gujarat, and also possibly the gently folded strata of the Kaladgi and Bhima beds for retaining artesian water, was unwilling to criticise the boring sites as recommended by the Committee without local knowledge and a careful personal exploration with the aid of large-scale geological maps. He also drew attention to the speculative nature of all deep borings in the Deccan Trap, either above or below the ghâts, and as to the desirability of preserving the cores brought up for examination by this Department.

59. It may very well be that besides fissures in the Deccan Trap, water also finds its way along the separation planes of the different trap flows, owing to the presence of porous intertrappean beds. The partially confirmed success of the Hubli boring is also of considerable interest. Although the yield of water was not stated, the fact that in a 300 feet boring water rose to within a few feet of the surface and recovered rapidly at 20 feet below that surface seems to show that it may be necessary to revise our notions as regards the steeply folded Dharwar rocks being too compact and impervious for the free passage of water and for artesian or semi-artesian conditions to exist.

60. **Ranchi.**—At the request of the Public Works Department of Bihar and Orissa, Mr. C. S. Fox in May proceeded also to Ranchi to report on the water-supply of the new Central Lunatic Asylum at Kanke, 4 miles north of Ranchi. For this investigation he was well-qualified by his previous experience of water questions in that locality during the preceding year, when in a very full report he had made various suggestions for deepening wells, increasing their yield by tunnels and a filter-crib in the bed of the Doranda stream, and for a small storage supply, in order to meet the increase demand of a growing town.

61. In the present enquiry 50,000 gallons daily were required to be assured. His suggestions for a reservoir, tube-wells and filter-cribs in the stream beds, were considered by him sufficient for the purpose. But, whatever the source or sources finally adopted, Mr. Fox recommended that the water should be supplied to the Asylum through small reservoirs to meet any sudden demand,

such as from fire, and that aero-motors should be used to work the pumps in the wells.

62. **The general question.**—It would seem from the above examples that the question of well water is one which is becoming a pressing one in many of the rather dry and well populated areas in India. In view of this, and of the undoubted fact that much obscurity still envelopes the problems of underground springs and water-saturated zones, it may be advisable in a future field programme (as suggested by my predecessor) to detail an officer to exhaustively examine the whole general question during one or more field seasons. This would not only conduce to a more scientific and complete settlement of the immediate question, but, incidentally, by the examination of the cores brought up by drilling, would be fruitful in geological and other data.

Engineering.

63. **Darjeeling landslips.**—Early in May Mr. R. C. Burton, was deputed to Darjeeling to make a geological survey of the Happy Valley landslip area, in continuation of similar investigations made in previous years by Dr. Hayden and Dr. Fermor. Furnished with a topographical map on the scale of 20 inches to the mile and showing 10 feet contours, which had meanwhile been completed down to the base of the slips, Mr. Burton was able to bring the geological examination of this area to an entirely satisfactory conclusion. He submitted a copy of the map with details inserted on it showing the structural condition of the rock, whether shattered or firm, the dip of the bedding and foliation planes, and the direction and localities of the folds and faults, cracks and fissures, traversing it. A descriptive account, supplementary to those of Dr. Hayden and Dr. Fermor, and embodying suggestions for protective measures, accompanied the map and was well illustrated by sections and photographs.

64. Whether or not the particular protective suggestions made by the Geological Survey, and which were afterwards discussed at a meeting of the Darjeeling Safety Committee, be finally accepted by the Government of Bengal, there can be no doubt that the completion of this structure map marks a step forward in the investigation of the Happy Valley slips.

GEOLOGICAL SURVEYS.

Bombay, Central India and Rajputana.

65. **Messrs. C. S. Middlemiss, H. C. Jones, A. M. Heron and N. D. Daru.**—Mr. Middlemiss remained in charge of the party at work in these areas, but did not himself take the field. The remaining members of the party, as noted in the margin, are the same as those of last year.

66. **Mr. H. C. Jones, Nimbahera District, Tonk State.**—Mr. H. C. Jones continued the survey of the Nimbahera District of Tonk State, which he began in the present writer's company towards the end of the previous season. The area worked lies between lat. 24° 25′ and 24° 45′ and long. 74° 18′ and 74° 51′ and is included in the 1″ to 1 mile Standard Sheets, Nos. 172, 173, 205 and 206 of the Central India and Rajputana Topographical Survey.

67. As noted in the last General Reports this area is broken up by large patches of territory belonging to Udaipur State in which work cannot be carried on at present and large tracts of the area are covered with alluvium. These combined with the disturbance caused by the intrusion of granite and basic dykes, makes the interpretation of the geology of the older rocks difficult. The area gone over rapidly by Mr. Jones and myself last season, together with the surrounding area was mapped by Mr. Jones in detail, and the general results once more confirm those made last season, that there is a continuous sequence of Vindhyan rocks stretching conformably downwards from the Kaimur sandstone, through the Suket shale, slabby limestone, purple shales and grits with the boulder bed near Binota at the base.

68. The geology to the south and west of the area is much more complicated, but there seems to be no doubt that Hacket's views of two older series is correct.—(1) the massive quartzites mapped by him as Delhis and (2) the schists, phyllites, shales, siliceous limestones and thin bands of quartzite, which he has mapped as Aravallis.

69. These massive quartzites, which occur as long ridges striking and often dipping in a similar manner to the Aravalli rocks, in places appear, owing to folding, to be interbedded with them, but in several places where the rocks have been cut across by streams, undoubted unconformities are seen. These quartzites are more of the nature of a hard sandstone than a quartzite and the oldest beds are usually conglomeratic in character.

70. Near the centre of the area the Aravalli rocks are intruded by a mass of granite and also by basic dykes, and in the extreme south-west of the area by granite veins. West of the granite, which runs in a roughly north and south direction through Pind, these Aravalli rocks are fairly well defined. They strike in a north-north-west direction but near the granite they are penetrated and disturbed by it, and are therefore somewhat confused. Working from it in a westerly direction there is a fairly well marked sequence from red-purple shale passing up into dark grey shales and phyllites, above which come chloritic schists. Then comes a band of gneiss, which is followed to the west by typical Aravalli schists,—at first dark mica schists, with occasional thin bands of hornblende, quartz and chlorite schists. Towards the west, the mica schist becomes full of small garnets, and still further to the west it contains excellent crystals of staurolite and chiastolite with some kyanite. Both the schists and the gneiss contain granite and quartz veins. Between the shales and the phyllites noted above there is sometimes a band of fawn-coloured siliceous limestone. This varies considerably both in character

and thickness and in parts seems to be entirely absent. It is largely covered and is much disturbed and cut up by the granite.

71. The gneiss, which appears to be a paragneiss, is very much crushed and altered. It is penetrated by numerous granite veins, which have also suffered from crushing, and which are probably of the same age as the granite near Pind.

72. The relationship of the rocks which outcrop between the granite and the Vindhyan boundary to the east is still doubtful and will probably remain so until the adjoining area of Udaipur State can be taken in hand.

73. The granite seldom makes any surface feature and is almost always covered with soil and alluvium. It is occasionally seen in river beds, and at the foot of the quartzite hills, where it has been protected by the harder rock. It is sometimes seen as small veins and veinlets running in all directions through the Aravalli rocks, but, with the exception of being broken up, no metamorphic action seems to have taken place. The rock is usually of a pink colour, containing very little ferro-magnesian minerals, and practically none of the accessory minerals commonly found in granites. A peculiar pinite granite occurs in parts and is similar to a rock found by the writer in Idar State.

74. Running roughly through the centre of the area in a north and south direction is a large basic dyke, which in parts seems to have spread out as a sill or flow. The rock is a coarse crystalline dolerite, but near the edges it becomes very fine grained and almost glassy in appearance. The dyke is of later age than the Aravallis and the granite, but its relation to the massive quartzites was not seen. Very little metamorphic action seems to have taken place between the dolerite and the Aravalli rocks, but near its junction with the limestone, south of Pind, it is associated with a vein of yellow green epidote, quartz and reddish idocrase. Where this large basic dyke is seen in contact with the granite a peculiar hybrid rock sometimes occurs, —there appears to have been a partial refusion of the granite, resulting in an intermixture of the granite and dolerite. The resulting rock, which has characters between the two, often shows remains of the ophitic structure of the dolerite, whilst there is also a micro-graphic intergrowth of the quartz and felspar.

75. Copper pyrites in small quantity was noted at several places in the schists, and a little galena was found in a thin band of Aravalli chert near Chikara, but with the exception of the flaggy limestone noted last season nothing of special economic importance was found.

76. **Mr. A. M. Heron: Jaipur, Karauli, Kotah and Tonk.**—Mr. Heron spent the early portion of last cold weather in examining sundry mineral occurrences which have already been noticed in last year's General Report. His survey proper in the States noted above was included within the 1″-1 mile Standard Sheets of the Central India and Rajputana Survey, Nos. 291 to 294, 318 to 321 and 341 to 343. Of these Nos. 291, 292, 293, 318, 319 and 341 have now been completely geologically surveyed.

77. Mr. Heron found the rock series to be composed of (*a*) Aravallis and (*b*) dark foliated granite or gneiss of unknown age. The Aravallis (*a*) build isolated hills and consist of quartzite and mica schist, obscurely stratified dipping irregularly and very highly altered. They contain numerous masses of intrusive granite identical with that already mapped by Mr. Heron as intrusive in the Delhis in Alwar and north Jaipur. It is very distinctly foliated in a direction coincident with that of the folding. There are also more recent veins of coarse tourmaline pegmatite, cutting through the granite, and which is never foliated. The hill at Koharsina (lat. 260° 54′, long. 75° 4′) exposes much schistose conglomerate unconformably overlying the Aravallis and which Mr. Heron thinks may be of Delhi age, though he was unable to settle this.

78. The dark foliated granite (*b*) found in the neighbourhood of Sakun (lat. 26° 42′ long. 75° 8′) is the same as that described by Mr. Heron in 1911-12, being very dark, micaceous, strongly foliated and visibly porphyritic or augen-bearing, the foliation planes being almost horizontal. It is traversed by pegmatite veins, quartz veins and by trap sills, the latter paralled with the foliation. A hint of its relative age is given by a small exposure just south of Asilpur Station (lat. 26° 54′ long. 75° 28′) where a very black micaceous augen gneiss, resembling the above, is intrusive in quartzite. The augen phenocrysts of pink felspar are so evenly arranged in straight lines with the foliation that the rock can be split into flags. Veins of normal pegmatite traverse it and also the quartzite.

79. Mr. Heron has included the work outlined above in a paper, which has been submitted for the *Records*, entitled " The Geology of Dholpur, Karauli and Southern Jaipur."

80. **Mr. N. D. Daru : Sunth, Banswara and Dungarpur.**—Mr. Daru completed the survey of Sunth State, Rewa Kantha Agency, part of which he had already surveyed in 1912-13. Mr. Daru describes the whole State as practically occupied by schist-like phyllites underlying massive quartzite, which in turn is overlain by phyllites. These three are said to be conformable. The lower or schistose phyllites often contain large proportions of quartz and hornblende, and, while the upper phyllites also at times have similar bands, they are generally argillaceous and include a few bands of quartzite. They are disposed in highly dipping anticlinal ridges. In the north-east parts of Sunth, and extending into Banswara State, there is a very soft, coarse sandstone, coarsely conglomeratic at the base, uncomformably overlying the phyllites, and having almost certainly the structure of a synclinal trough. Its age is uncertain, but as none of the pebbles appear to be derived from the neighbouring Bagh beds or Deccan Trap, but consist of quartzite and its associates, the soft coarse sandstone may be older that the latter.

On the south east and east boundary of the State the Bagh calcareous conglomerate, 20 to 50 feet thick, forms a horizontal elevated platform on which appear hillocks and ridges of Deccan Trap. No minerals of economic importance have been met with.

81. Towards the end of the cold-weather season, in March and April of 1914, Mr. Daru revised certain portions of Banswara and Dungarpur States. The results he proposes to embody in a connected report on the whole, which he is now preparing.

Burma.

82. The Burma party consisted of Messrs. G. H. Tipper, G. de P. Cotter H. S. Bion, and M. R. Ry. Sethu Rama Rau, Sub-Assistant.

83. **Mr. G. H. Tipper.**—Mr. Tipper, who was placed in charge of the party, visited Yenangyaung, the Minbu-Ngape section, the Yaw river (in company with the Director and Mr. Cotter), Ngahlaingdwin, and the Sinbaungwe township.

84. **Mr. G. de P. Cotter.**—Mr. Cotter, continued the systematic survey of the Pauk township and the Saw township, Pakokku district. Part of the field season was devoted to an investigation of certain coal seams discovered by him in this neighbourhood; the results of this have been published in the *Records*, Vol. XLIV, part 3. At the end of the season he made a traverse in the Pakokku hill-tracts as far as Kanpetlet (sheets 84 K. 3, 4, 6, 7, 10 Burma Survey).

85. **Mr. H. S. Bion.**—Mr. H. S. Bion worked in the Saw and Salin subdivisions of the Minbu and Pakokku districts (sheets 84 L 1, 5, 6, K 4, 8, Burma Survey).

86. **Area investigated.**—The area investigated by these two officers forms a long strip of undulating country comprising the foot-hills of the Arrakan Yomah between latitudes 20′ 30″ and 21′ 45″ and running north and south parallel to, and east of, the main range.

87. **Structure.**—In this tract the structure is in general a normal sequence of Tertiary beds dipping towards the east below the Irrawaddi sandstones and faulted against the older rocks of unknown age composing the main range of the Arrakan Yomah. This sequence is broken by asymmetric anticlines with their corresponding synclines near Ngahlaingdwin (94° 22″ 40″; 20° 41″ 15″) and at the Yaw river (94° 21″ ; 21° 17′). The asymmetry is on the western flank and associated with it is reversed faulting. In the case of the Ngahlaingdwin anticline the reversed fault, after running north for some distance as a strike fault, curves round and probably dies out as a dip fault near Saw.

88. **Main geological results.**—The principal results of the joint work of Messrs. Cotter and Bion may be thus briefly indicated:—

(1) The recognition that the Tertiary series of strata underlying the Irrawaddi sandstones is more extensive than was formerly thought to be the case. At present no definite estimate can be given of the thickness, but it is probably approximately 24,000 feet. The series consists of alternations of sandstones,

shales and clays, the basal member being composed of conglomerates and ashy sandstones. It shows no unconformable break. The lithological resemblance between the different shale and clay bands is very striking. Local names have been adopted temporarily for many of the divisions and further work will show how far these are capable of wider adaptation.

(2) Traced from south to north, there is a gradual change from marine to fluviatile and estuarine conditions. Clay bands which are prominent in the neighbourhood of Ngahlaingdwin have become sands in the region of the Yaw river and are indistinguishable from the overlying sandstones. As a consequence of this lithological change, the faunal and lithological subdivisions are not in agreement from south to north. It is quite clear that the gulf, in which it may be assumed this series of beds was laid down, silted up at an earlier period in the north, the shallow water beds of the north thus being contemporaneous with deeper water deposits further to the south.

(3) The "Red Bed," usually taken as the boundary between the Irrawaddi sandstone and the underlying formation, and which has proved of such value in unravelling the stratigraphy of the oilfields, is not of the same age throughout. The "Red Bed" no doubt represents an old land surface and as such indicates an interruption of sedimentation, but such conditions were established at an earlier date in the north than in the south.

(4) It is not possible at present to say definitely the limits of age represented by this series of beds. Fossils occur at many horizons, but the collections have not yet been completely studied. A few fossils collected by Mr. Cotter on his traverse to Kanpetlet seem to indicate an upper Cretaceous age for the lowest beds.

89. **Irrawaddi Sandstone.**—In the course of his survey, Mr. Cotter found a very good bone bed near the village of Chaingzauk (sheet 84 K. 10). The remains, chiefly teeth, have been identified by Dr. G. E. Pilgrim, and include :—

Stegodon clifti (molars).

Sus giganteus.

Hippopotamus sp. cf. *irravaticus* (*molars*).

Rhinoceros sp. cf. *sivalensis.*

Amphibos sp.

A large antelope allied to *Hippotragus.*

Teeth and horn cores representing a new genus of antelope allied to *Boselaphus.*

90. **Recent river changes.**—The Irrawaddi river, the Salin chaung and the Yaw river have all in recent times changed their courses as indicated by the distribution of the older river gravels. In the case of the Salin chaung the course has been greatly lengthened by the change.

91. **Sub-Assistant Sethu Rama Rau.**—Sub-Assistant Sethu Rama Rau was engaged during the earlier part of the field season in mapping the Tertiary beds of the Sinbaungwe and Allanmyo townships of the Thayetmyo district (sheet No. 158 Burma Survey).

92. **Pegu series.**—The major part of this area is occupied by rocks of the Pegu series folded into three approximately parallel anticlines and synclines running in a N. W., S. E. direction. Local folding and crumpling accompanied by faulting are common. On lithological grounds Sub-Assistant Sethu Rama Rau thinks it is possible to make four sub-divisions in this area. It has not been possible to correlate these with any of the sub-divisions established in the north as, although the beds are fossiliferous, the collections made were lost in a village fire. Except on the banks of the Irrawaddi and in some of the stream-beds, exposures are everywhere poor, the rocks being concealed under a thick alluvial covering.

93. The Irrawaddi sandstones and the more recent formations present no features of interest.

94. In the latter part of the season, Sub-Assistant Sethu Rama Rau was engaged in assisting Mr. Cotter in opening up coal-seams in the neighbourhood of the Yaw river, Pakokku district and in collecting fossils from the lower Tertiary beds of the same district.

Central Provinces.

95. **Dr. L. L. Fermor, Messrs. H. Walker, C. S. Fox, R. C. Burton and M. Vinayak Rao.**—The Central Provinces party during the year consisted as before of Dr. L. L. Fermor, Messrs. H. Walker, C. S. Fox, R. C. Burton, and Sub-Assistant M. Vinayak Rao, of whom Dr. Fermor and Mr. Walker were absent on leave in Europe during the field season of 1913-14, but returned to the party in November. Mr. K. A. K. Hallowes was then also attached to the party for the ensuing field season, being deputed to the Mandla district.

96. **Dr. Fermor's inspection tour.**—During parts of November and December Dr. Fermor visited Messrs. Burton and Hallowes in the field, examining with Mr. Burton some of the interesting features in western Balaghat elucidated by the latter during the previous field season, particularly the relationships of Mr. Burton's Sonawani series to the Chilpi Ghat series, and the sedimentary and crush-conglomerates bounding the south-eastern margin of the Chilpi outcrop in this region, as seen at Kaspur Tola and other localities. The undoubted autoclastic character of some of these conglomerates led Dr. Fermor to re-examine the rock underlying the Balaghat manganese-ore deposit,

which he had previously described as a schistose conglomeratic grit, and to agree that it also must be regarded as an autoclastic rock. These crush conglomerates consist now almost entirely of sericite and quartz, but every stage of the transition from felspathic gneisses can be traced.

97. In his visit to Mr. Hallowes in the Mandla district, a commencement was made in the detailed mapping of an area of Deccan Trap lava flows in the north-western portion of the Mandla district. Seven flows were identified, of which the middle five had an average thickness of 98 feet. A system of faulting with small throws up to about 30 feet was also detected; and, in the Balein Nadi, a nearly circular patch of volcanic agglomerate, $25' \times 17'$, strongly suggestive of a small volcanic plug, was detected in a water-worn exposure of the second flow from the base.

98. The work in the Central Provinces is leading to the discovery of a surprising number of cases of faulting of post-Deccan Trap age. Early in 1913 Mr. Burton discovered a case, near Alesur in the Seoni district, of the preservation by block faulting, with a downthrow of 40—50 feet, of a strip of Deccan Trap resting on gneiss. In the same year Messrs. Fermor and Fox, whilst revising their map of the Deccan Trap lava flows in the Linga area, detected a small fault with a throw of about 50 feet and found indications of other faults, whilst in the past field season Mr. Fox discovered numerous examples of faulting of post-Deccan Trap age, in Northern Chhindwara. Dr. Fermor now reports the discovery near Utekata in the Chhindwara district of a spindle-shaped strip of Deccan Trap, about two miles long and three-quarters of a mile wide in the middle, and resting on biotite-gneiss and calc-gneiss, that has been let down 250 feet by block-faulting. The faulted block is itself much faulted by a system of smaller faults with throws of 15—30 feet. The majority of faults referred to above have strikes lying between E. 30°N. and E.30°S. This suggests the possibility that to a certain extent the present elevation of the Satpura range above the plains to the north and south may be due to a system of block-faulting of post-Deccan Trap age. Mr. Burton also deduces the existence of block-faulting of comparatively recent age from a study of numerous small hanging valleys on the southern edge of the Satpuras in the Seoni district. A fine example of such a hanging valley is also afforded by the Nakta nala in the Chhindwara district. From a study of the base of the Deccan Trap on the two sides of the Kanhan valley from Ramakona southwards in the Sausar Tahsil, Chhindwara district, Dr. Fermor deduces that this valley must lie along a fault of approximate N. N. W. strike with a down-throw of about 250 feet to the west.

99. **Mr. C. S. Fox: Chhindwara.**—Mr. C. S. Fox continued his survey of the Chhindwara district, working as before in the Chhindwara and Jagir Tahsils. In the previous year Mr. Fox had divided the Archæan crystallines into three main zones :—(1) a zone of acid ortho-gneisses lying to the south of the latitude of Lawaghogri; (2) a zone of gneisses and schists of obscure origin lying between the latitudes of Lawaghogri and Chhindwara; and (3) a belt

of intrusive porphyritic and fine-grained granites running through Chhindwara town. This season's work has led to the discovery of a fourth large group of rocks, namely a considerable area of metamorphosed sediments of Dharwarian facies, composed of grits, quartzites, phyllites, and flags, and exposed around Bhatoria and along the southern edge of the Chhindwara coal fields. These sediments are intruded not only by the Chhindwara granitic batholith, but their strike is also interrupted by two smaller batholiths of similar nature, named by Mr. Fox the Raini and Kunkal batholiths after peaks rising to 2,986 and 2,905 feet respectively, which are the highest summits yet detected amongst the Archæan exposures of this districts. Mr. Fox's mapping shows beautifully the way in which these granitic batholiths have modified the strikes of the ancient sediments. Since with increasing intensity of metamorphism the rocks of Dharwarian facies are seen to pass into the rocks of the second zone referred to above, these latter are now regarded by Mr. Fox was para-gneisses. Great masses of intrusive basic rocks have also been mapped. They are older than the granitic batholiths and intrusive with reference to all the other crystalline rocks. They are now mostly in the form of epidiorites and amphibolites, and were introduced as dykes and sills of dolerite and gabbro, sometimes carrying olivine, remnants of the original pyroxenic rocks being sometimes found. Instead of the characteristic alteration into amphibole, the pyroxene has occasionally been changed to biotite, as near the village of Gorakpur (22°6′—78°37′). The amphibolites, where subjected to intense shearing pressure, have sometimes become garnetiferous. Mr. Fox also describes a case near the village of Mankughati (22°7′—78°32′) in which a band of amphibolite has been marginally converted into crystalline limestone.

100. Mr. Fox also extended his survey through the Jagir country along the Chhindwara-Narsinghpur road to the northern margin of the district, this route lying for the most part on Deccan Trap ; but in the northern corner of the district the Shakar and Hard rivers have cut through the Trap and exposed the underlying Gondwana beds of Jabalpur age. These Gondwanas are pierced by dykes of olivine-dolerite, and a great intrusive sheet of the same rock, which shows the effects of repeated post-Trappean step-faulting. In the high tracts of Deccan Trap lying between these Gondwana outcrops and the latitude of Amarwara to the south, Mr. Fox estimates the existence of 1,200—1,500 feet of lava, with the complete absence of fossiliferous Intertrappeans. South of the latitude of Amarwara and Singori the Deccan Trap never exceeds about 500 feet in thickness, and is built up of seven to eight flows with one to three fossiliferous Intertrappean horizons. Mr. Fox suggests that the upper part of the Jagir traps corresponds with the middle traps of the classification given on page 262 of the Manual of Geology of India (2nd Edition), and that there was either an overlap of the flows from south to north, or that the granite ridge formed by the three batholiths already mentioned sharply separates the two areas. The belt of Gondwana rocks underlying the Jagir traps, and which are exposed as the Chhindwara coal fields along the

southern edge of these traps, has, according to Mr. Fox, been preserved by trough faulting; and in considering the possible extension of the Gondwanas to the east Mr. Fox thinks that there is little doubt that the upper Gondwanas are continuous under the trap eastward to Jabalpur. The question of the extension of the Gondwana rocks under the Deccan Trap of Western India is considered on page 114.

101. **Mr. R. C. Burton: Seoni and Balaghat.**—During the season 1913-14 Mr. R. C. Burton completed the survey of those portions of the Seoni district allotted to him, thus, with Sub-Assistant Vinayak Rao, completing the survey of this district. As in the previous season, the chief formations examined were laterite, Deccan Trap, and Archæan gneisses and metamorphosed sediments, the results being a continuation of those of the previous season. In the northern parts of the district Mr. Burton records eight Intertrappean horizons, which, if really distinct, indicate the presence of nine flows of trap, with a total thickness of 775 feet, and an average thickness for the lower eight flows of 92 feet; but in view of the existence of block faulting in the Satpuras, the above figures may require some modification. Mr. Burton describes some interesting cases of amphibolites passing into hornblende-gneiss, apparently, by absorption of quartz from the associated older granite.

102. From the classificatory point of view the geological survey of the Balaghat district will probably prove to be of critical importance in the establishment of the true sequence of Archæan formations of the Central Provinces. West of the Wainganga are the alluvial plains of the Katangi-Waraseoni area of western Balaghat, fringed on the north by the foot-hills of the main Satpura range; whilst to the east of this river lies a hilly plateau tract, forming a southward projecting spur of the main Satpura range and known as the Maikal range. This spur has an average elevation of about 2,000 feet and forms the natural continuation of the strike of the highly metamorphosed Archæan gneisses and sediments constituting the 1,000 feet Nagpur-Balaghat plain; and as it contains the same formations in a less metamorphosed form it will probably afford better material for the deciphering of the stratigraphical succession. During this season Mr. Burton surveyed a considerable portion of the Katangi-Waraseoni plain and the hills to the north, but at the end of this season he crossed the Baihir plateau forming part of the Maikal range and examined at Chilpi Ghat the type locality for the Chilpi Ghat series established by Dr. King in 1885. This section shows a great thickness of phyllites and slates with tufaceous quartzites, separated by coarse felspathic grits from a basement conglomerate 450 feet thick, which rests unconformably on a gneissic complex. There is also a great thickness of intrusive basic rocks. The conglomerate carries rolled pebbles of quartzite, gneiss, jasper, granite, and phillite; and indicates the previous existence of a still older sedimentary series. The Chilpi Ghat series, as is known from the work of P. N. Bose, extends into Western Balaghat, where Mr. Burton finds it to be composed of the same rocks as in the type locality, including the tufaceous quartzites, but without the basic intrusive sills and with a relatively insignificant basal con-

glomerate. In the hills north of the Balaghat plain Mr. Burton finds an important development of ancient metamorphosed sediments composed in descending order of (1) phyllitic schist and quartz-muscovite-schist, (2) felspathic quartzite, (3) quartz-muscovite-schist, (4) calc-gneiss and crystalline limestone, the base of the series not being seen. Although the evidence is not yet clear, Mr. Burton thinks that this series of sediments must be situated u conformably below the base of the Chilpi conglomerate. He consequently proposes to call it the *Sonawani series*, after the village of Sonawani situated on one of the largest outcrops of these rocks. If this two-fold sub-division of the Archæan sedimentaries of Balaghat into the Chilpi Ghat series and the Sonawani series can be definitely sustained it will be a great step forward. At present, however, owing to the intense folding and thrusting which the rocks of Western Balaghat have undergone, the existence of this unconformity, although probable, has not been definitely proved. Dr. Fermor regards the Chilpi Ghat series as the local equivalent of portions of the Dharwar system of Southern India Whether the Sonawani series is to be regarded as a lower sub-division of the Dharwar system or as a district geological system as widely separated from the Chilpi Ghat series as the Grenville series is from the Temiskamings of Canada, will depend upon the value assigned to this unconformity. Another interesting point arises from this suggested separation of the Sonawani series. In his account of the manganese-ore deposits of the Central Provinces Dr. Fermor has distinguished two modes of occurrence of manganese-ores and associated manganese-silicate rocks. The chief mode is the gondite series of rocks situated near the base of the Chilpi Ghat series ; as an important but distinct mode of occurrence he records the existence, in association with crystalline limestones, of manganese-ore deposits with associated spessartite, rhodonite, and piedmontite-bearing rocks. Since Mr. Burton assigns to the calcareous rocks a position near the base of his Sonawani series, we apparently have the interesting case of two distinct series of Archæan sediments, each distinguished by the deposition of manganiferous sediments close to the base. In a table in his progress report, attempting the correlation of the Archæan rocks of India, Mr. Burton suggests the equivalence of the calc-gneisses of Vizagapatam with those of the Central Provinces. This is in accord with the association of manganese-pyroxenites with calc-gneisses at Taduru and Chintelvalsa already referredto (see page 36) and suggests that the material for the formation of the koduritic rocks, if they really be hybrids as suggested by Dr. Fermor, has been derived from manganiferous rocks of age corresponding to the lower manganese horizon of the Central Provinces.

103. The ideas advanced by Mr. Burton concerning the origin of the calc-gneisses and the crystalline limestones of the Sonawani series are referred to on page 35.

104. In addition to the sedimentary conglomerates Mr. Burton has discovered numerous cases of crush-conglomerate and related rocks developed in the Archæan formations of this area. The most peculiar of these takes the form of flattened ellipsoidal and tabloid-like bodies developed in biotite-

gneisses and granite and evidently due to crushing. These bodies, which are autoclastic portions of the rock in which they lie, now consist almost entirely of quartz and sillimanite. The conversion of the potash-felspar of the original rock into quartz and sillimanite is supposed by Mr. Burton to have taken place in two stages during dynamic metamorphism, muscovite being first formed under more moderate pressures and becoming converted into sillimanite as the metamorphism became more intense. The biotite apparently may have passed direct into sillimanite. The alteration processes involve the removal of potassium, magnesium, and iron in solution, probably as carbonates, as can be shown by chemical equations.

105. The work in the Central Provinces is confirming the old idea that the Satpura range, as we now know it, is the denuded remnant of an ancient mountain chain and that its elevation is connected with the folding of the rocks constituting it. This idea is supported both by Mr. Fox and Dr. Fermor and the latter has maintained[1] that the intrusion of the granites which formed such a large portion of the Satpuran core was intimately bound up with the tectonic movements to which the Satpuras owe their elevation, suggesting that the intrusion of the granite was the cause of the upheaval. Mr. Burton, from a study of the evidence in Balaghat and Seoni, indicates that the folding movements preceded and permitted the intrusion of the batholithic granitic rocks, and that the intrusion was succeeded by thrusting movements, of which there is abundant evidence in the form of the crush-conglomerates already referred to.

106. **Sub-Assistant M. Vinayak Rao: Seoni and Mandla.**—Sub-Assistant M. Vinayak Rao continued his work in the Seoni district, mapping parts of sheets 70, 78, 87, 88, 89, and at the close of the season commenced work in sheets 109, 110 in the Mandla district. The formations examined were Archæan gneiss, granite, Deccan Trap, Intertrappeans, laterite, and alluvium, by far the greater portion of the area being covered by Deccan Trap. A great thickness of trap was found towards the western border of the district, where there may be as much as 1,500 feet of lavas. Near Arjunjhir (22°18′—18°0′) six Deccan Trap dykes from one to six feet thick were discovered, ramifying and joining together to form a multiple dyke. Six Intertrappean bands were detected, but they yielded no fossils. In the Mandla district in addition to Deccan Trap, the Narbada alluvium proved to be of considerable importance. It is in places as much as 150 feet thick and near Cheolia (22°50′—80°2′) yielded an implement fashioned from Deccan Trap flint.

Kashmir.

107. **Mr. H. S. Bion.**—Mr. Bion followed up his work of last year in a north-west direction between the Sind river at Sonamarg and the Wular lake at Bandipur, a region which includes the Haramuk massif and the extensive

[1] *Mem. Geol. Surv. India* XLI, p. 165.

watershed of ridges separating the Jhelum and Kishenganga drainages (1 inch =1 mile sheets 43 N-3, 43 J-15 and parts of 43 J-11 and J-16).

108. During the survey of this rough mountainous tract he has filled in a good many gaps in the evidence (previously referred to in the General Report for 1912, *Records*, *Geological Survey of India*, Vol. XLIII, pt. 1, p. 38) tending to show that within the distance from the Lidar valley to the Wular lake the Punjab Trap has shifted its position from one confined to a pre-Permian horizon to one extending up to the base of the Upper Trias. The evidence may now be considered to be conclusive on this point, as also regarding the manner of that transgression, which all the circumstances of the case favour being one ordinary volcanic effusion (with production of amygdaloidal bands and also pumiceous and ashy beds) and as having taken place at progressive times in different localities, so that the whole set of lavas, dovetailed with the respective sedimentaries, belong to one connected and continuous phase of vulcanicity. As interesting steps in the proofs supplied by Mr. Bion may be mentioned the finding of flows interbedded with the Permian of Nichinai and of a limestone mass containing typical Muschelkalk fossils, such as *Buddhaites Rama*, entirely surrounded vertically and laterally by bedded traps. The same chain of observations makes it probable that the Imbersilwara limestone, about which doubts have prevailed, is of Lower Triassic age, and is also an isolated lenticle limited in every direction by trap.

109. Over most of the area the Panjal Trap immediately overlies the Slate Series, the Muth Quartzite and Syringothyris Limestone having died out by rapid overlap of the Panjal Trap in the neighbourhood north-west of Gagangiyer, to which place they were originally traced by Mr. Middlemiss.

110. The fossils of the Nagmarg horizon coming below the traps of that place, and originally mentioned (*loc. cit.* p. 38), have been largely worked out by Mr. Bion and will be described in a separate paper. They are considered by him to be of Uralian age, and separated from the Zewan beds only by the Artinskian plant beds of the Guryul ravine, Nagmarg and the Golabgarh pass. The large number of Spirifers found at that horizon, such as *Sp.* nov. sp., and varieties of the Australian *Sp. Stokesi* Koenig, which show closely related and ancestral characters to Zewan forms, is greatly in favour of this.

111. In his detailed progress report Mr. Bion has also described the local modifications of the Permian and Trias horizons, and has added many notes on trap dykes, and on the granite of Wangat and Margund, the latter being considered to be of Devonian age. His observations on the glaciology of the area round Haramuk are of much interest; a great many large and fine moraines have been mapped, some descending to 6,500 feet altitude and perhaps even to 1,000 feet lower than this. Mr. Bion has been led to suspect the former existence of two glacial periods in Kashmir separated by a long interglacial one.

112. Museum Assistant A. Subba Iyer was placed with Mr. Bion for collecting purposes and for instruction in field-work. Mr. Bion found him very

willing and anxious to do his best but the nature of the work was perhaps too difficult and complicated for one untrained in the rudiments of field-work.

TRANS-FRONTIER EXPLORATION.

Chitral, Chinese Turkestan and Pamirs.

113. **Dr. H. H. Hayden.**—In the course of a recent journey to Europe through Chitral and the Russian Pamirs, Dr. Hayden made collections of rocks and fossils, which reached Calcutta from Kashgar towards the end of the year. From notes supplied by Dr. Hayden it would appear that the hills of Dir and Swat consist chiefly of basic igneous rocks followed by a series of unfossiliferous, and often metamorphosed, sediments resembling the Purana rocks of the Himalaya. These are separated by a wide belt of granite from a group of agglomerate and trap, evidently the western representatives of the Panjal trap and Agglomeratic Slate of Kashmir. This group of beds is well seen below Drosh in the valley of the Chitral river.

114. In Upper Chitral an interesting stratigraphical series, extending probably from Cambrian to Cretaceous, was found along the Yarkhun river. Interruptions by faults and by intrusive masses chiefly of granite, render the sequence discontinuous, but it was found possible to make fairly extensive collections of fossils; the Upper Devonian beds, from which specimens had already been described by Hudleston in 1902[1] yielded an especially fine collection of brachiopods and corals. At the head of the Yarkhun valley, on the divide between Chitral and the Afghan province of Wakhan, Carboniferous and Permian beds near the Baroghil and Shawitakh passes contain an interesting fauna comprising *Brachiopoda*, *Bryozoa*, *Fusulinæ* (with *Schwagerina*) and *Nautili*.

115. In the Yasin valley, between Gilgit and Chitral, a slaty limestone full of hippurites was found among highly metamorphosed sediments, and Dr. Hayden is inclined to regard the metamorphic rocks of Gilgit, Hunza, Nagar, and N.-W. Kashmir as to a great extent merely the altered representatives of the sedimentary beds of Chitral and as ranging in age from Lower Palæozoic to Cretaceous.

116. Interesting collections were also made in the Pamirs, and Chinese Turkestan, where Dr. Hayden met with the greatest kindness at the hands of the respective Russian and Chinese officials, and particularly at the hands of Sir George Macartney, British Consul-General at Kashgar. In the Russian Pamirs the most persistent and conspicuous stratigraphical element is a very thick limestone series ("Pamir Limestone") containing well-preserved Jurassic ammonites in its upper beds. It was probably from the lower beds of the same Pamir Limestone that Stoliczka collected the Triassic genus

[1] *Geological Magazine*, Vol. IX, 3-8, 49-58 (January, February, 1902).

Halorella near Nezatash in 1874. The limestone in underlain by a great series of shale, sandstone and conglomerate full of intrusions of basic rocks.

117. In the northern Pamirs, at the eastern foot of the Ak Baital pass, which lies between the Rangkul Pamir and Great Kara Kul (lake) a limestone near the roadside yielded a small fauna of Upper or Middle Devonian age.

118. Dr. Hayden's collections also include *Gryphœa Kaufmanni* (=*Ostrea turkestanensis* Rom.) from the Ferghana stage of the Tertiary of Chinese Turkestan and the Alai, and Fusulina limestone from the latter range.

119. The chief interest of the observations made in Chitral and the Russian Pamirs lies in the fact that, as had been anticipated, they serve to a great extent to explain the differences between the Afghan and Himalayan stratigraphical provinces. The strike of the rocks conforms completely to the general structural conditions indicated by the deep re-entrant bay of alluvium in north-western India ; in western Chitral it is approximately S.W.—N.E. gradually bending round, in the mountains surrounding the upper Yarkhun valley, in Yasin and in Gilgit, to W.-E. and finally trending onwards to N.W.—S.E. in the Taghdumbash pamir and Sarikol. It would appear, therefore, that the basin in which the fossiliferous series of Upper Chitral were deposited is the westerly continuation of the geosynclinal of Spiti and Ladakh, and unless obliterated by intrusive igneous material, ought to be found again in the Karakoram range. Indications of its presence there are, indeed, said to have been met with by members of the Filippi expedition during the course of their recent researches.

GEODESY.

BY

LIEUTENANT-COLONEL G. P. LENOX-CONYNGHAM R.E.,

Superintendent of the Trigonometrical Survey.

TRIANGULATION.

Note.—The Sambalpur series having just been completed it was decided to postpone further principal triangulation until after the War, and to confine secondary triangulation to the completion of work in hand and to those series which may soon be wanted for the support of the topographical programme. Under this arrangement it was found that one officer would only be required for a small part of the season in Assam, so he utilised the remainder of the season in reconnoitring the proposed Chittagong Series of principal triangulation which is to connect the Burma Coast series with the Manipur meridional. The programme carried through was therefore as follows :—

PRINCIPAL TRIANGULATION—BENGAL, ASSAM AND BURMA.

Chittagong Hill Tracts, Lushai and Chin Hills.

The Chittagong Series.—This series was reconnoitred and all stations built, from a base on the Burma Coast series about 30 miles east-north-east of Chittagong, along a line keeping near the main road to Lungleh in the Lushai Hills, and thence due eastwards almost up to a base on the Manipur Meridional, east of Falām and Hāka in the Chin Hills. The series has been very satisfactorily laid out and forms a connection across 115 miles of difficult country by means of 5 strong figures all giving double values. The final connection with the Manipur Meridional was not quite completed owing to unfavourable weather, and it seems that we shall have to connect with the Eastern side of the Manipur Meridional by means of an extra quadrilateral. This matter can very easily be settled, and will involve the building of one extra station, when observing work is commenced from the Burma end. The 10 new stations bringing the series to this doubtful junction have all been built, and very full notes have been recorded for the assistance of the principal detachment which will ultimately have to observe the series. In addition to the new series laid out, it has been found that the whole hexagon of the Burma Coast series, at the western end of the work, will probably have to be reobserved, owing to a number of the old markstones having been destroyed.

SECONDARY TRIANGULATION—CENTRAL INDIA AGENCY.

Gwalior and Narsinghgarh States.

The Ashta Series.—The remaining eight stations of this series, completing its junction with the Karachi Longitudinal, were observed. The work commenced at the side just north of the railway and west of Shujalpur station, and closed on the stations Dawa and Rangaon of the Karachi Longitudinal series.

An 8-inch micrometer theodolite was used, and the average triangular error was 2·″18, the maximum being 3·″30. The closing errors were 0·0000246 in log side, 0·″28 and 0·″25 in latitude and longitude, and 2 feet in height, which is quite satisfactory.

After the completion of this small remnant of work the detachment carried out the observations of the Middle Godāvari Series.

HYDERABAD STATE.

Districts Nander, Nizāmābād, Adilābād and Karīmnagar.

Middle Godāvari Series.—This series had been laid out in 1911-12 under the title of the *Bhir Series.* The series connects the Great Arc and the Jabalpur Meridional Series along the line of the Godavari valley. The length of the series is 137 miles, and it involves observations at 18 stations.

An 8-inch micrometer theodolite was used, the average triangular error was 1·″25 the maximum being 3·″67. The closing errors were 0·0000047 in log side, 0·″07 and 0·″09 in latitude and longitude, and under 2 feet in height. This is very satisfactory.

Thirty additional points were fixed by intersection, for the assistance of topographers.

ASSAM.

Districts Kohimā, Cachār, and Nowgong.

The Cachār Meridional Series.—This is a meridional series connecting the Assam valley series at a base east of Nowgong with the end of the Cachār Branch or Manipur Longitudinal series. Its chief object was to obtain supplementary evidence in regard to the rather unsatisfactory connection between these two old series given by the Naga Hills series in the previous year. Unfortunately various difficulties prevented the final figure to the north, making connection with the Assam Valley series, from being observed before the weather broke. It moreover seems possible that to complete this connection about 2 triangles of the old Assam Valley series may have to be reobserved, owing to markstones having been disturbed. The remaining portion of the work is however in easier country and should be less subject to unforeseen delays than that which has been put through.

Ten new stations were built, and twelve observed at during the season. A 12-inch micrometer theodolite was used, and the average triangular error was 1·″5, the maximum being 2·″8.

The Kohimā Series.—This is a longitudinal series connecting the Naga Hills series with the Cachār Meridional in continuation of the old Khāsiā and Jaintia Hills series which lies to the west of the Cachār Meridional. The whole of the stations were built, and the eastern portion observed last year. During the current season the work was completed, involving observations at 8 stations.

An 8-inch micrometer theodolite was used and the average triangular error was 1·″6, the maximum being 3″·7.

ASTRONOMICAL LATITUDES.

The report of last year mentioned the regions in which observations for latitude were made in the cold weather of 1913-14 but as the computations were not completed in time for that report the results could not be given.

The following table gives the co-ordinates of the stations in the Bombay Coast area together with the observed deflections of the plumb line, that is the difference between the Astronomical and the Geodetic Latitudes, (A-G); a negative sign denotes that the plumb line is deflected to the North and a positive sign that it is deflected to the South.

The table includes all the latitude stations in the area whether observed at in 1913-14 or previously.

Table.

Name of Station.	Latitude.	Longitude.	Height.	Deflection of Plumb line, A-G	Situation.
	° ′	° ′	Feet.	″	
Parnera . .	20 33	72 57	614	—7·02	4 miles from coast.
Kalsubai . .	19 36	73 43	5,400	—3·87	Summit of Ghats, 70 miles from coast.
Colaba . .	18 54	72 51	75	—10·33	Coast.
Karanja . .	18 51	72 56	997	—11·20	2 miles from coast.
Kankeshvar .	18 44	72 56	1,260	—10·27	3 miles from coast.
Mira Dongar .	18 41	73 10	1,863	—5·71	Isolated hill 20 miles from coast.
Alibag . .	18 39	72 52	10	—10·34	Coast.

Table—contd.

Name of Station.	Latitude.	Longitude.	Height.	Deflection of Plumb line, A-G.	Situation.
	° ′	° ′	Feet.	″	
Mandvi	18 38	73 35	4,121	—3·17	Summit of Ghats, 40 miles from coast.
Dhauleshvar	18 26	74 12	2,939	+1·20	On an easterly spur of the Ghats, 80 miles from coast.
Mahableshvar	17 55	73 40	4,719	—5·64	Summit of Ghats, 40 miles from coast.
Mirya	17 2	73 16	473	—6·27	Coast.
Majala	16 47	74 29	2,613	—1·37	On easterly spur, 75 miles from coast.
Mavinhunda	16 25	74 50	2,582	+0·28	On easterly spur 90 miles from coast.
Chaukola	15 56	73 59	2,794	—6·50	Summit of Ghats, 25 miles from coast.
Kundgol	15 15	75 17	2,147	—0·82	85 miles from coast.
Kumbhari	15 9	74 18	2,898	+2·51	Summit of Ghats, 25 miles from coast.
Honnavalli	14 17	75 13	2,775	—1·70	Deccan plain, 50 miles from coast.
Koramur	14 8	75 1	2,527	—4·88	Easterly spur of Ghats, 30 miles from coast.

The stations all lie in a strip of country about 400 miles long and less than 100 miles wide, the western edge of which is the Bombay Coast.

This coast runs nearly north and south and one would not have expected to find any relation between the deflection of the plumb line and the distance from the coast but the observations show a distinct connection.

The stations may be divided into 4 classes, *viz.* :—

(*a*) Coast stations.

(*b*) Stations lying inland between the coast and the foot of the Ghats.

(*c*) Stations on the ridge of the Ghats.

(*d*) Stations lying east of the ridge, where the Ghats drop down into the Deccan plateau.

The stations of class (*a*) with their deflections are :—

	″
Parnera	—7·02
Colaba	—10·33
Karanja	—11·20
Kankeshvar	—10·27
Alibag	—10·34
Mirya	—6·27

Of class (*b*) there is only one :—

	″
Mira Dongar	—5·71

Those of class (*c*) are :—

	″
Kalsubai	—3·87
Mandvi	—3·17
Mahableshvar	—5·64
Chaukola	—6·50
Kumbhari	+2·51

Those of class (*d*) are :—

Dhauleshvar	+1·20
Majala	—1·37
Mavinhunda	+0·28
Kundgol	—0·82
Honnavalli	—1·70
Koramur	—4·88

The largeness of the deflections at the stations of class (*a*) and the smallness of those at the stations of class (*d*), with the exception of Koramur-are very noticeable.

Another remarkable feature is the existence of an area of maximum northerly deflection near Bombay, where there are 4 stations with deflections of over 10″.

The magnitude of the deflection falls off whether we move north towards Parnera (—7″), south towards Mirya (—6″) or inland towards Mira Dongar (—6″) and Mandvi (—3″).

At Colaba, Karanja, Mandvi and Dhauleshvar Astronomical Azimuths are available, whence the deflections in the Prime vertical can be deduced. The results are very remarkable : they are :—

Colaba, deflection in Prime Vertical	7·3 West
Karanja ,, ,,	15·2 West
Mandvi ,, ,,	15·4 East
Dhauleshvar ,, ,,	9·3 East

The change of 8″ in 8 miles between Colaba and Karanja ; and that of 30″ in 40 miles between Karanja and Mandvi are very surprising. The former especially so, as the two stations lie on opposite sides of Bombay harbour

and all the visible conditions point to a change, if any, in the opposite direction.

Calculations of the deflection in the Prime Vertical based on the theory of Isostatic Compensation by Hayford's methods, have only been made for Colaba, but it can be safely predicted that these sudden changes are not susceptible of explanation on any general hypothesis; they must be due to some local peculiarity of structure.

In the report of 1913-14 the results of some pendulum observations in this region were given. They indicated the presence of something abnormal, for at Colaba gravity was in considerable excess and at Alibag it was in defect. The figures obtained were :—

—	Without compensation.	With compensation.
	$g-\gamma_b$	$g-\gamma_c$
Colaba	+0·062	+0·063
Alibagh	—0·005	0·003

This seems rather to indicate a belt of low density, and therefore of low attractive power, running from some point to the south of Alibag in a north-east direction so as to pass to the East of and not far from Karanja.

The additional pendulum observations which had been planned for the field season of 1914-15, but which had to be abandoned owing to the War would have thrown valuable light on the state of things. These observations will be undertaken as soon as normal conditions are re-established.

Besides those that have been under discussion, Latitude observations were made at one station in the outer Himalayas and at three in the plains at the foot of the hills. The results are given below.

Station.	Latitude.	Longitude.	Height.	Deflection A—G.	Situation.
	° ′	° ′	Feet.	″	
Godhna . .	29 37	77 54	846	—9·73	Plains, 30 miles from foot of hills.
Mehesari . .	29 30	78 9	811	—10·03	Plains, 25 miles from foot of hills.
Harpalsid* .	29 40	78 33	1,000	—28·60	Close to the foot of the hills.
Ranigarh . .	30 4	78 43	7,005	—29·67	Outer hills, 25 miles from foot.

* The observations were not made at the Triangulation station but in the plains at the foot of the hills about 2 miles from the station.

The deflections are similar to those obtained at similarly situated stations elsewhere.

They confirm the views already formed as to the presence of an area of low density along the foot of the hills and add to the detailed information that is by degrees being accumulated.

PENDULUM OPERATIONS.

Owing to the war no fresh gravity observations have been made. Professional Paper No. 15, which will sho·tly appear, will bring the pendulum operations to a definite stage which may now be conveniently reviewed.

In addition to the annually published reports of the pendulum observers, the work as a whole has been summarised and discussed almost up to date in the two Professional Papers Nos. 10 and 15.

Professional Paper No. 10 gives the results of the first 39 pendulum stations observed at in India during the 4 seasons from the spring of 1904 to the spring of 1907, together with a full discussion of the preliminary observations taken at Kew and Greenwich in 1903 before the pendulums were brought to India. The paper contains full details of the observations with a discussion of probable errors, and closes with a comparison showing the difference between the observed results and those computed on the assumption of a homogeneous condition of the earth's crust.

After the publication of this Professional Paper Mr. Hayford of the United States Coast and Geodetic Survey brought forward his new method of investigating gravity results in reference to various assumptions regarding crustal compensation. The work of applying this method to Indian results was commenced in 1910, and has been steadily carried on since in conjunction with the collection of further data by pendulum observations.

The new Professional Paper, No. 15 gives full details of the gravity results obtained at the 70 stations visited during the 6 years 1907-1913.

The gravity results available to date, are :—

	Stations.
1904-1907	39
1907-1913	70
1913-1914	10
TOTAL .	119

These stations are well distributed in India and Burma, so as to give a good idea of the general state of affairs in most parts of the country. Professional Paper No. 15 gives "Hayford" and "Bouguer" corrections as computed for 73 selected stations, discussing the methods and principles involved, and the relative accordance of the observed results with various hypothetical conditions of compensation in the earth's crust.

The paper also contains a full discussion of instrumental difficulties and improvements, together with a summary of the results of Paper No. 10 and a brief comparison of modern gravity results with those obtained 40 years ago and described in Volume No. 5, of the Account of the Operations of the Great Trigonometrical Survey.

Since the pendulums were brought to India in 1903 there have been 3 opportunities of comparing them with other sets of first class pendulums, as follows :—

In 1905 Dr. Hecker swung the pendulums of the Prussian Geodetic Institute alongside of ours at Jalpaiguri, as described in Professional Paper No. 10. In 1906 Commander Alessio made observations at Colaba in the same room as had been used by us in 1904; and in 1913 the same officer with Signor Abetti swung the Italian pendulums alongside of ours at Dehra Dun, in connection with Cavaliere de Filippi's expedition to the Pamirs, as described in Records of the Survey of India, Volume V. The results of this last comparison together with the other gravimetric data subsequently obtained by the Italian expedition are not yet available.

The results of the first two comparisons were however most satisfactory. Our adopted value of g at Dehra Dun, from our connection with Kew, which had previously been connected with Potsdam, is 979·063 cm sec^2. The results of the Prussian pendulums, based directly on Potsdam, differed from ours at Jalpaiguri by only +0·002 while the Italian pendulums based on Potsdam *viâ* Genoa gave a value at Colaba differing from ours by —0·000004. We have therefore every reason to hope that the results of the recent direct comparison at Dehra Dun may prove equally confirmatory of our adopted value.

Since the preparation of Paper No. 15, Hayford corrections have been computed for some 19 of the 46 stations not yet treated. This work will be carried on as opportunity offers pending the resumption of operations with a full staff.

LEVELLING OPERATIONS.

During the year 1914-15 the following lines of precise blevels on the new system of "fore and back double levelling" were run :—

(*a*) *In the Punjab.*

From Multan *viâ* Lodhran to Bahawalpur.

(*b*) *In the United Provinces.*

Revision of the line from Meerut *viâ* Moradabad to Bareilly. This line was originally levelled in 1867-68-69.

From Bareilly *viâ* Budaon to Hathras.

From Benares to Karamnasa along the Grand Trunk Road. This forms part of the line which will probably be carried on to Howrah next season.

(c) In Bihar and Orissa.

From Karamnasa to Barakar. This is part of the Howrah-Benares line. Branch lines were also run along the Patna Canal from Barun to Belsar and from Bankipore to Bihta.

(d) In the Bombay Presidency.

From Bagalkot *viâ* Hungund to Nagarhal. This is part of the line which starts from Raichur.

From Bagalkot *viâ* Kolhar and Mulvad to Bijapur.

In addition to the above about 50 miles of single levelling were carried out in the City and Island of Bombay, in order to supply a sufficient number of heights of points for Municipal purposes and for incorporation in the Bombay City Survey Maps.

(e) In the Nizam's Dominions.

From Raichur to Nagarhal. This is part of the line which was carried on to Bagalkot.

(f) In the Madras Presidency.

Revision of the line from Bellary *via* Guntakal to Gooty. This line was originally levelled in 1873-74.

Each section of the lines of levels in the Punjab and in the United Provinces, except the portion between Benares and Karamnasa was levelled twice over in opposite directions on widely different dates, whereas for the remaining lines each section was also levelled twice over in opposite directions but on the same day.

The total outturn of levelling amounted to about 945 miles, out of which it was found necessary to relevel 145 miles in both directions owing to the differences between the results of the two levellings exceeding the prescribed limits as laid down in the resolution passed at the International Geodetic Conference of 1912.

TIDAL OPERATIONS.

During the year tidal registrations by automatic gauges have been continued at the following ports :—

Aden, Karāchi, Apollo Bandar (Bombay), Prince's Dock (Bombay), Madras, Kidderpore, Rangoon, Moulmein and Port Blair.

The tide-gauges at all the above observatories have, on the whole, worked satisfactorily, no serious interruptions having occurred anywhere.

The tidal observatory at Port Blair was shifted to a new site about 30 yards to the south of the old one at the request of the Chief Commissioner of Port Blair in consideration of local requirements. The new observatory was constructed in advance and when the Tidal Inspecting Officer reached Port Blair for his annual inspection, the instruments were removed from the old building and installed in the new one on 1st March 1915, so that no break occurred in the continuity of the tidal registrations.

The predictions of the times and heights of high and low water for the year 1914 were found to have been practically of the same standard of accuracy as those for the year 1913 at all the nine stations named above.

At Bhavnagar, Chittagong and Akyab observations of high and low water were taken on tide-poles during daylight, with the object of testing the accuracy of the predictions which are based on the automatic tidal registrations taken at these ports many years ago.

OPERATIONS AT DEHRA DUN.

BY

MR. J. DE GRAFF HUNTER.

During the last year owing to the reversion of many officers to military duty the continued study in the field of the form of the geoid in the neighbourhood of Dehra has not been possible.

A considerable amount of time has been devoted to the problem of finding the changes to the co-ordinates,—latitude, longitude and azimuth,—of triangulated points which will arise if the spheroid of reference is changed. This problem has been solved satisfactorily and the results are now passing through the press (Professional Paper No. 16). The problem occurs in any question of plumb line deflections, which clearly depend on the spheroid to which they are referred. Four quantities are available for choice of values best suited to the observed deflections, namely the changes in the semi-major and semi-minor axes of the spheroid of reference, in the latitude of the origin of the survey and in the azimuth of the initial ray through the origin. The case of change of longitude of the origin need not be considered as it merely affects all longitudes by a constant amount. Denote these four changes by δa, δb, u_0, w_0, the change in longitude being v_0. The effect of any one of these four changes can be computed separately and independently of the others. This is a great advantage, as if this is done, say for $\delta a = 1$ km. the effect of making δa, any other amount, say 830 metres, is obtained by simple multiplication by 0·830. Moreover with this may be combined the three other changes in any desired proportions. This makes the solution perfectly general and does not restrict it to any proposed change of axes.

The solution is actually put in the form of tables which give the coefficients, appropriate to any latitude and longitude, in the following equations for changes of co-ordinates :—

Latitude change $= w = A\ \delta a + B\ \delta b + C\ u_0 + D\ w_0$.

Longitude change $= v = v_0 + A'\delta a + B'\delta b + C'u_0 + D'w_0$.

Azimuth change $= w = A''\delta a + B''\delta b + C''u_0 + D''w_0$.

δa, δb being expressed in kilometres and u, w in seconds.

The coefficients are tabulated for the corners of each degree square.

If then any change of axes and origin is proposed these equations enable the effect at any point to be written down. Or it would be possible to select any or all of the latitude, longitude and azimuth stations and in each case to form equations as above. The solutions of these equations by minimum squares will give values of the deflection of the vertical at Kalianpur in both meridian and prime vertical, as well as values of the most probable changes of the axes from those used in the computation of the Indian triangulation (Everest's axes). This is merely stated in illustration of the possibilities opened out by the solution of the original problem : it is not suggested that the above method would necessarily give an accurate value of the spheroid which best fits India. This would depend largely on the discretion used in selecting undisturbed stations. Thus it would be useless to try to explain the irregularities in Himalayan Districts entirely by changes of axes and origin. None the less in considering these irregularities the effect of the spheroid must be given due weight ; and, in addition, the effect of the attraction of visible masses and of suspected defects or excesses of density in the Earth must be estimated. The difficulties of a general explanation of all observed deflections are considerable. In attempting to treat these deflections mathematically the calculation of the attractive effect of visible topography is very troublesome. Compensation of a sort is known to exist : but there is much uncertainty as to its nature and degree of completeness. Allowance should also be made for local deviations in density from the assumed average value for the crust. Any new theory of compensation makes necessary a whole series of very troublesome computations to test its validity. The simplest of the above processes of calculation is that for visible topography : for there, at least, the existence of the masses dealt with is not hypothetical. The general plan has been to calculate the effect at each station by dividing up the Earth's surface by great circles through the station and small circles around it as pole. In this way the surface is divided into a set of compartments of geometrical form. The average height of each compartment is estimated, and this quantity after some minor corrections have been applied, is multiplied by a suitable factor, and the product combined with corresponding expressions for all compartments gives the total effect. The minor corrections are for height of station above sea level and for the effect of the curvature of the Earth's surface. In this process it is

difficult even to separate the land effect from the water effect, and a more detailed separation is out of the question.

An instrument has been designed and is now under construction to perform the integration of the attraction of any mass on the Earth by simply running its pointer round the several contours shown on the map. This, if satisfactory, will certainly make it possible to treat the features of the Earth separately. The advantage of this process is that these effects can afterwards be combined according to any new theory without the labour of recomputation. The instrument automatically takes full account of curvature of the Earth and height of station. It is hoped that with the help of this instrument it will be feasible to find the effect on deflections of the various main features separately. The effects can be reduced to tables in the same way as has been done for the axes changes. As an example the following sub-divisions might be made for India.

(1) The ocean,

(2) The Indian Continent,

(3) The Indo-Gangetic plain,

(4) The Himalayas,

(5) The Tibetan plateau,

(6) Surrounding countries.

The effect of the visible topography of each of these features on the assumption of normal density may be found and expressed in tabular form. It would then be possible to write down at once the effect of any one feature—say the Himalayas—on the latitude at any station. If there was any reason to suppose that the density of the Himalayas was so many per cent. different from normal, this would be represented by multiplying the result by a percentage factor. Next consider compensation. Isostatic compensation complete at a certain depth and uniformly distributed through that depth has been assumed by Hayford in order to make an approximation in calculation to what is probably a more complex distribution. But there is reason to believe that the compensation of the Himalayas is not of precisely the same nature as that of the Indian continent : and that both differ in this respect from the ocean. It is accordingly proposed to find by means of the instrument the effect of a defect of mass equal to that of the topography occurring in successive depths of say 0-5, 5-10, 10-20 etc., miles, each of these effects being multiplied by a percentage factor. Thus if C_5 C_{10}....are these compensation effects the total actual compensation effect will be $f\,C_5+f'C_{10}+\ldots$ ....where f f'are unknown factors. In this way it is hoped to take account of compensation being incomplete, of its extending to different depths, and of its distribution in depth being other than uniform. The Hayford hypothesis does **not** admit of a variation in the depth at which compensation is complete, nor do the methods of computation hitherto in use make it

possible to take account of different distributions of density underlying different parts of the earth's surface.

The total effect of a feature and its compensation will then be:

α(Feature Effect)+f C_5 +f′C_{10}+..........=F, say, where α is a factor to represent abnormal density. Combining the several features and forming equations to satisfy observed deflections an equation of the following form will be derivable from each latitude or azimuth station,

$$F_1+F_2+F_3..........+A\ \delta a+B\ \delta b+C\ u^0+Dw^0$$
$$=\text{observed deflection.}$$

Observation data for some 400 such equations are available. Their solution by minimum squares may throw a good deal of light on many theories in need of decision. Much work however will be necessary to carry this out.

Wireless Longitudes.—Reference was made last year to the wireless longitude arcs observed in collaboration with the de Filippi Expedition. Subsequently to last year's report, observations at three more stations, Suget Karaul, Yarkand and Kashgar, were successfully carried out. These three stations are situated beyond the great Karakoram Range, and it was an open question to what extent the mountains would interfere with the signals. The results have shown that the mountains did not form a serious obstacle. The triangulation data obtained by the Expedition are not yet available, so that in no case can plumb line deflections be given at present. The fixing of the longitude of Yarkand and Kashgar in Greenwich terms through the connection with India is of considerable geographical importance.

Indo-Russian Connexion.—The results of the Russian observations have now been received. The Russian triangulation starts from a station whose observed latitude and longitude are 40° 37′ and 72° 56′ respectively. The semi-axes of the Bessel spheroid on which the Russian triangulation is computed exceed those of the Everest spheroid by 121 and 6 metres respectively. If the Russian triangulation is applied to the Indian triangulation taking account of this fact, and making the position of Kukhteh and also the azimuth of Sarbloc agree, the resulting value of the latitude of the first Russian station 40° 37′, 72° 56′, exhibits a Southerly deflection of about 9″ on the Everest spheroid. On the Clarke-Bessel spheroid this deflection is increased to 16″ Southerly. This is of interest, since it is the first latitude observation in the Himalayas showing a Southerly deflection, and indicating that what may roughly be called the line of Himalayan attraction has been crossed.

BOTANY.

1—BOTANICAL SURVEY

BY

MAJOR A. T. GAGE, I.M.S., M.A., M.B., B.Sc., F.L.S., F.A.S.B.

Director, Botanical Survey of India.

Eastern India.—Collections were made in the Darjeeling District by Mr. C. C. Calder, while officiating as Director, by Mr. G. H. Cave of the Lloyd Botanic Garden, Darjeeling, by Mr. E. A. C. Modder of the Kurseong Forest School and by the late Mr. H. J. C. Kinghorn of Kalimpong. From the Eastern Himalaya two new species of *Meconopsis* (*M. decora* and *M. argemonantha*) have been described by Sir David Prain and a new species of *Sedum* (*S. Prægerianum*) and a new variety of *Plumbaginella micrantha* Spach have been published by Mr. W. W. Smith. A new genus *Lacaitea* of *Boraginaceæ* has been formed by Brand to accommodate a specimen collected by Mr. Lacaita below Kalimpong, and hitherto identified as *Trichodesma calycosum* Coll. & Hems. Other new species from the Eastern Himalaya are *Dioscorea lepcharum* Prain & Burkill, *Piper sonadense* C.DC. and *Piper nigramentum* C. DC. An interesting discovery has been that of *Unona præcox* Hf. & T. on the Government Cinchona Plantation Mungpoo. This Anonaceous species has hitherto been collected only once in the Mikir Hills of Assam.

From Assam, Rai Bahadur Upendranath Kanjilal of the Forest Department has contributed excellent collections, while Mr. P. M. Deb Burman, Assistant in the Botanical Survey, has contributed collections made during his holiday in Tipperah. Towards the end of the year Dr. H. G. Carter of the Botanical Survey investigated the economic plants, apart from those that come under the purview of the Forest and Agricultural Departments, cultivated in the District of Lakhimpur. As this work is still unfinished detailed reference is deferred. Incidentally as a point of interest in plant distribution it may be noted that one of the worst weeds of cultivation in that district is *Oxalis corymbosa* DC. a South American species that has spread to various other subtropical countries. The same weed has recently been collected in the Darjeeling District, and it is possible that it may give trouble there also in the future. The following species of *Dioscorea* from Assam have been published as new by Sir David Prain and Mr. I. H. Burkill :—*Dioscorea Arachnida, D. Clarkei, D. trinervia* Roxb. but not ex Wall.

No officer of the Botanical Survey was able to visit Burma during the year and circumstances have interfered with the aid given so liberally in

the past by persons not officially connected with the Botanical Survey. None the less a considerable amount of work has been done in working out past collections by Botanists in India and in Europe, and the following new species have been described :—GERANIACEÆ—*Impatiens Allanii* Hook. f. ; ILICINEÆ —*Ilex Englishii* Lace ; SABIACEÆ—*Meliosma Mannii* Lace ; LEGUMINOSÆ— *Crotalaria shanica* Lace, *Dunbaria gracilipes* Lace, *Derris Lacei* Dunn, *Millettia subpalmata* Dunn, *M. utilis* Dunn, *Acacia Maingayii* Lace ; RUBIACEÆ— *Adina indivisa* Lace, *Hedyotis dimorpha* Craib, *Mycetia gracilis* Craib ; COMPOSITÆ—*Centrantherum burmanicum* Gamble ; MYRSINACEÆ—*Ardisia gracilis* Lace ; ERICACEÆ—*Rhododendron burmanicum* Hutchinson ; GENTIANACEÆ —*Cotylanthera coerulea* Lace ; ACANTHACEÆ—*Thunbergia maculata* Lace ; LAURACEÆ—*Alsoedaphne Keenani* Gamble (also in Assam) ; THYMELÆACÆ— *Edgeworthia longipes* Lace ; EUPHORBIACEÆ—*Euphorbia minbuensis* Gage, *Acalypha Lacei* Hutchinson ; ORCHIDACEÆ—*Ione flavescens* Rolfe, *Arundina subsessilis* Rolfe, *Renanthera pulchella* Rolfe ; DIOSCOREACEÆ—*Dioscorea membranensis* Pierre MSS., *Dioscorea tentaculigera* Prain & Burkill, *D. velutipes* Prain & Burkill, *D. Rogersii* Prain & Burkill, *D. Brandisii* Prain & Burkill ; GRAMINEÆ—*Spodiopogon Lacei* Hole.

A number of new species from the Malayan Peninsula has recently been published, and as Hooker's Flora of British India takes in that Peninsula they may be mentioned here. They are :—ANONACEÆ—*Goniothalamus caudifolius* Ridley ; MAGNOLIACEÆ—*Talauma singapurensis* Ridley ; VIOLCEÆ—*Alsodia grandiflora* Ridley, *A. hirtella* Ridley ; BEGONIACEÆ—*Begonia Rajah* Ridley ; EUPHORBIACEÆ—*Cleistanthus hirsutopetalus* Gage, *C. prætermissus* Gage, *Phyllanthus filicifolius* Gage ; FAGACEÆ—*Pasania Kingiana, P. lampadaria, Castanopsis malaccensis, C. Scortechinii, C. fulva, C. Andersoni, C. megacarpa, C. Ridleyi*, all by Mr. Gamble ; GNETACEÆ—*Gnetum Kingianum* and *G. Wrayii* by Mr. Gamble ; CONIFERÆ—*Agathis flavescens* Ridley ; DIOSCOREACEÆ—*D. tamariscifolia* Prain & Burkill, *D. stenomeriflora* Prain & Burkill.

Western India.—The second part of Father Blatter's Flora of Aden has appeared, giving descriptions and distribution and synonymy of species belonging to the families from *Menispermaceæ* to *Euphorbiaceæ*. The final part of this work is in the Press and about to issue. Mr. L. J. Sedgwick, I.C.S., has published a list of grasses from Ahmedabad and Surat with notes on their habitats, ecological relations and time of flowering. He enumerates 34 genera and 73 species. Dr. Stapf has published a new species of *Combretaceæ,—Anogeissus coronata* from Rajputana.

Northern India.—The first part of Vol. III of Mr. J. F. Duthie's Flora of the Upper Gangetic Plain containing descriptions of the species in the families from *Nyctaginaceæ* to *Ceratophyllaceæ* has been published, while a continuation of the work bringing it up to the end of *Orchidaceæ* is in the Press.

Mr. S. R. Kashyap of the Government College, Lahore has investigated the morphology and biology of new and little known Liverworts of the Western

Himalaya, and has described a new genus *Sewardiella* and the following new species :—*Sewardiella tuberifera, Fossombronia himalayensis, Anthoceros erectus, A. himalayensis, Exormotheca tuberifera, Stephensoniella brevipedunculata, Plagiochasma articulatum, Cryptomitrium himalayense.* A new species of *Meconopsis,* (*M. latifolia*) from the Western Himalaya has been described by Sir David Prain, and a new *Sedum* from Kumaon (*S. Magæ*) by M. R. Hamet.

Central India.—The higher cryptogamic vegetation of Pachmari and its neighbourhood has been studied by Mr. J. R. D. Graham, the Economic Botanist to the Central Provinces. He enumerates thirty-four species of ferns belonging to 18 genera, one Equisetum (*E. debile* Roxb.) two Lycopodiaceæ (*Lycopodium cernuum* and *Psilotum triquetrum*) and two Selaginellas (*S. rupestris* Spreng. and *S. proniflora* Baker.). From the same locality Mr. H. H. Haines has described a new species of fig,—*Ficus cupulata* and from the Satpura hills a new fleshy Euphorbia (*E. caducifolia*), and from the Chanda District a new Euonymus (*E. godavarensis*). The same Botanist has concluded his list of Trees, Shrubs and Economic Herbs of the Southern Forest Circle of the Central Provinces.

Southern India.—The Government Lecturing Botanist Madras and his assistants collected in Chingleput, South Arcot, Salem, Coimbatore, Malabar, South Kanara, the Dhimbam Ghats, the Kollimalais of Trichinopoly, Vizagapatam and the Kallakad Hills of Tinnevelly. During part of July and August 1914, Mr. M. S. Ramaswami, Senior Assistant in the Botanical Survey explored the Veligonda Hills of the Nellore District and the Rampa country in the Agency Tracts of the Godavari District. Altogether about 560 species were collected, some of them new. In March and April 1915 Mr. C. C. Calder, Curator of the Herbarium made a second trip to Travancore State to explore the vegetation of the hills drained by the Achincovil and Kallar rivers between latitudes 9° and 9°15′ North and East longitudes 77° and 77°15′. From the Anamalai Hills excellent collections have been contributed by Mr. C. E. C. Fischer of the Forest Department. Rao Sahib M. Rama Rao, Conservator of Forests, has published a preliminary list of the flowering plants of Travancore, with notes on their uses.

The most important work concerned with Southern India is the Flora of the Madras Presidency now under preparation by Mr. J. S. Gamble, M.A., C.I.E., F.R.S., and Mr. S. T. Dunn, M. A., F. R. G. S. The elaboration of the material placed at their disposal has incidentally brought to knowledge a considerable number of new species. Mr. P. F. Fyson, B.A., of the Presidency College, Madras has also contributed notably to our knowledge of the vegetation of the Presidency and has described a considerable number of new species. The following additions to the known flora of the Madras Presidency have been published during the year :—RANUNCULACEÆ—*Clematis Bourdillonii, C. theobromina* by Mr. Dunn ; ANONACEÆ—*Sageræa grandiflora* Dunn, *Uvaria eucincta* Bedd, ex Dunn, *Goniothalamus rhynchantherus* Dunn, *Unona Ramarowii* Dunn ; CAPPARIDACEÆ—*Capparis fusifera* Dunn ; MAL-

VACEÆ—*Hibiscus setinervis* Dunn; STERCULIACEÆ—*Eriolæna Lushingtonii* Dunn; LEGUMINOSÆ—*Crotalaria Bourneæ* Fyson, *C. conferta* Fyson, *C. ovalifolia* Wall, ex Fyson; RUBIACEÆ—*Lasianthus coffeoides* Fyson; OLEACEÆ —*Olea Bournei* Fyson; EBENACEÆ—*Diospyros Barberi* Ramas.; PIPERACEÆ—*Piper pykarahense* C.DC., *Peperomia Meeboldii* C.DC., *P. cochinensis* C.DC.; DIOSCOREACEÆ—*Dioscorea Trimeni* Prain & Burkill (from Ceylon), *D. Kalkapershadii* Prain & Burkill; COMMELINACEÆ—*Aneilema pulneyensis* Fyson; ERIOCAULEAÆ—*Eriocaulon Christopheri*, *E. Geoffreyi*, *E. Mariæ*, *E. mysorense*, *E. Oliveri* all by Mr. Fyson.

General..—Father Blatter has published a further instalment of his comprehensive account of the Palms of British India and Ceylon, the species described during the year belonging to the genera—*Howea*, *Heterospatha*, *Roscheria*, *Nephrosperma*, *Verschaffeltia*, *Phœnicophorium*, *Acanthophoenix*, *Oncosperma*, *Hydriastele*, *Rhopalostylis*, *Cyrtostachys*, *Ptychosperma*, *Loxococcus*. Dr. Beccari has almost ready for press a continuation of his account of the *Lepidocaryeæ* tribe of Palms of Asia. Sir David Prain has published an account of some additional species of *Meconopsis*, with a key to all the known species, many of which are indigenous to the Himalayas.

Dr. J. C. Willis, formerly of Ceylon, has published an important paper on the endemic Flora of that island, with reference to geographical distribution and evolution in general. He has found that the local endemic species have not been developed in any kind of advantageous response to local conditions, and that they are much rarer than those species which are also common to Peninsular India, and these again than those of wider distribution. Another conclusion drawn by Dr. Willis is that on the average the commonness of a species depends upon its age from the time of its arrival in or evolution in the country. There is no reason to suppose that the well separated species of the Ceylon genera with many endemics owe their separation to the destruction of intermediate types. The facts adduced by Dr. Willis support very strongly the hypothesis that the whole tree of descent of a family may exist on the earth at the present moment and that the area occupied is in general an indication of the age of the species or genus if it has not already attained its maximum.

A synopsis of the Dioscoreas of the Old World, exclusive of Africa, has been published by Sir David Prain and Mr. I. H. Burkill. One hundred and seven species are enumerated, ten new Indian species being described, one new from Ceylon and two from the Malayan Peninsula.

M. C. deCandolle has worked out the Indian *Piperaceæ* collected by Mr. A. Meebold and has described five new species. Mr. N. E. Brown late of the Kew Herbarium staff, has published a historical summary and an account of the distinguishing characters of the genera *Dracæna Pleomele Sansevieria* and *Tæstsia*. Mr. W. G. Craib has made further contributions to our knowledge of the Flora of Siam and incidentally of Burma.

The writer has described new species of *Euphorbiaceæ* from India and Malaya and has contributed to the Dutch publication "Nova Guinea" an account of the *Euphorbiaceæ* collected by various recent Dutch expeditions in New Guinea. Mr. W. B. Turrill has discussed *Hedychium coronarium* and its allied species and has separated off a new species *H. subditum* from *H. flavum* Roxb., with which it had been confused. Mr. R. N. Parker has published a useful list of new Indian species of Forest importance published during 1913, in which he mentions 108 species. Mr. R. A. Rolfe has discussed the synonymy of the Orchid *Sarcanthus oxyphyllus* and has cleared up a long standing confusion.

Miss M. L. Cleghorn has published an interesting paper in which she describes the mechanism for the trapping and release of small beetles for effecting cross-pollination in *Typhonium trilobatum* a species of Aroid common in Bengal. Mr. M. S. Ramaswami has described the modifications of the leaf structure of *Zoysia pungens* Willd., a sand grass of the Madras Coast. He shows that the modifications are adaptations to make the best use of the limited water supply, to prevent excessive transpiration, to withstand the mechanical strain due to winds and to shut off the intense glare of the sunlight. The same botanist has recorded, with figures, the considerable range of variation in the form of the leaves of *Heptapleurum venulosum* Seem. Mr. H. N. Chibber of Gujarat College has published an account of the germination of *Barringtonia acutangula* Gærtn., *Trapa bispinosa* L. and a species of *Crinum*.

Additions to the Indian Flora.—During the year about 90 species of flowering plants have been added to the known Flora of India, Burma, Ceylon and the Malayan Peninsula.

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BOTANY.

II.—ECONOMIC BOTANY.

Part I.—Agricultural Botany

BY

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The present report deals with the results obtained in Economic Botany in India during the year ending June 30th, 1915. The programmes of work in progress in this subject have already been published and are to be found in full in the last issue of the *Proceedings of the Board of Agriculture in India*. A list of papers published during the year is appended.

Cotton. Beyond one paper by Mr. Leake, there is very little of a purely botanical nature to record in the case of this important crop. In the current volume of the *Agricultural Journal of India*, this investigator discusses in detail the problems involved in the building up of improved cottons in the United Provinces from various indigenous Indian types. The progress so far made and the difficulties encountered in producing the ideal cotton, by plant-breeding methods, are also dealt with. While the new cottons so far isolated do not reach the ideal standard, nevertheless a considerable amount of progress has been made. Further crossing, which is now in progress, will be necessary before any further advance can be made and this is necessarily a matter of time. Considerable attention has been paid to the evidence which exists as to the limits within which improvement of the local cotton crop is possible. As regards the idea that long staple cannot be combined with an early maturing habit, the author considers that the facts point to the opposite conclusion and that there are no grounds to justify the belief in the mutual repulsion of long lint and early maturity. Indeed, from certain *Nurma* crosses, Mr. Leake obtained early maturing forms with long staple cotton which only lacked one character, namely, vigorous growth of the reproductive branches, to make its cultivation remunerative. As regards the relation between high ginning percentage and fineness of fibre, the evidence is not so favourable and there appear to be valid reasons for considering the two characters to be, to a certain extent, mutually exclusive. It would seem that fine cottons can only have a moderate fibre weight, and consequently, only a moderate ginning percentage. From this it follows that the cultivator must be paid

fairly for improved quality, if he is ever to take up the cultivation of long-stapled cottons for the Lancashire market.

As pointed out in the last report, the chief difficulties with regard to the improvement of Indian cotton, particularly where quality is concerned, arise *after* a better cotton has been obtained at the Experiment Stations. Unless the country crop can be replaced entirely by the new form, all kinds of difficulties arise in practice connected with natural crossing in the field, with fraudulent adulteration of the lint and seed, with the mixing of seed at ginneries and in obtaining a proper price for the cotton, particularly in the early stages of the work. Where there is no question of improved quality but only the increased yield of a short stapled variety, the difficulties with regard to purity of seed are not encountered to the same degree. These matters were dealt with in detail in the last report and the various schemes of improvement, in which a better quality cotton is involved, were contrasted with those in which yield is the first consideration. During the present year, two interesting papers have appeared on these questions which deal with the present position of affairs in Madras and in the Central Provinces respectively.

The history of cotton improvement, in the Tinnevelly and Ramnad Districts in Madras, has been described by Mr. Sampson and the story is typical of the difficulties which are met with all over India in establishing a cotton, characterized by an improved staple. Such schemes are naturally much more difficult than those in which a higher yield is the main feature. The efforts to improve the cotton crop, in the area where " Tinnevelly " is grown, commenced in 1905 when a detailed survey of the area was begun. In the north of the tract, the *uppam* variety was found to predominate while, in the south, the variety *karunganni* was held in greatest esteem. There was, however, a good deal of admixture of these two forms all through this region. The best villages were those which preferred to hand gin the *kapas* and to sell their lint, while the worst were those which sold all their *kapas* and depended on outside dealers for their seed. At first, an attempt was made to distribute improved seed of both these varieties, *uppam* in the north and *karunganni* in the south, but experience showed that too much was being attempted with the means available and it was decided to restrict the work to the southern half of the tract and to improve the *karunganni*. The operations were based on the Koilpatti Agricultural Station and in a short time seed, sufficient to sow 10,000 to 12,000 acres of pure *karunganni* each year, was distributed. This naturally had a considerable effect on the quality of the cotton. New ginning factories were put up by cotton buying firms in the tract, mainly on account of the superiority of the crop. These factories, combined with two or three seasons of short crop, were found to have undone the work of the Department in keeping the crop pure. "In 1912, it was found that what a year or two previously had been practically a pure *karunganni* tract was again a hopeless mixture of ' bazaar ' seed. Although ginning factories under proper management do much to maintain the quality of export cotton by having the ginning under control, their introduction tells very

seriously on the quality of the seed sold for sowing. Village dealers, instead of ginning the village *kapas* by hand and selling the lint, now dispose of the *kapas* to travelling dealers who trade directly through the brokers employed by the factory. Consequently, all *kapas* whether good or bad is mixed, bad samples are graded up with good, *kapas* which will not pass muster is similarly graded up till it does. The crops in the neighbourhood of these factories further showed that much of the seed had been brought from a distance. *Kapas* instead of being stored dry, as formerly, is now often collected straight from the field and packed immediately. The result is that much of the cotton heats and the vitality of the seed is either weakened or altogether destroyed." Thus the initial efforts of the Agricultural Department to produce a large area of pure *karunganni* were of no avail. In 1912-13, the work was started afresh with improved selections, obtained from the local crop, and efforts were made to control the seed supply and to concentrate the improved cotton in certain villages. The new type now distributed is a great improvement on the country crop both in yield and in quality. In 1914, it yielded on an average 620 lb. of *kapas* per acre against 454 lb. for ordinary mass-selected *karunganni*. It had a ginning percentage of 31·3 against the district average of 25 and the spinning tests showed it was quite suitable for spinning 40's against 26's for the ordinary selected *karunganni*.

In the Central Provinces, Mr. Clouston has published a detailed account of the history of the recent work in cotton improvement in Berar where a robust, high-yielding type of short-stapled *roseum* has been distributed. The work has grown very rapidly of late and this year as much as two million pounds of seed were distributed to cultivators. With the rapid increase in the number of farms, it became evident that concentration was necessary in order to guarantee more efficient supervision. "With the assistance of the Registrar of Co-operative Societies, some of the seed farms have been converted into the Central Farms of Co-operative Agricultural Seed Unions. Each Union consists of ten or more members, each of whom guarantees to grow only selected *roseum* cotton and to keep all the seed for distribution. The number of villages included in the Union may vary from one to ten. Each Union has a central seed farm or farms comprising an area of from 25 to 100 acres to which selected seed is supplied every year from the Akola farm. The areas sown with *roseum* by the other members of the Union have been designated branch seed farms. The main purpose of the central farm is to supply pure seed to the branch farms, but when more seed is produced on the central farm than is required for the branch farms of the Union, it is sold as part of the Union stock of seed. It is the duty of the Department to see that only pure selected seed is supplied to the central farm and that only pure seed is handed over to the branch farms ; while it is the duty of the Union *kamdar* to see that the seed of the branch farm is kept pure."

A consideration of the above schemes, which are typical of Indian conditions as a whole, leaves no doubt that the question of the permanent improvement of Indian cotton is now largely a matter of efficient District organiza-

tion, the aim of which must be complete replacement of the country crop by the improved kind over definite areas. Where yield only is concerned and the cultivator can obtain at once the reward of his labour, the experience of Berar shows that the spread of any new kind is largely a question of energy and good organization. Where, as in South India, quality as well as yield is involved, the difficulties are much greater and, to obtain success, much closer supervision of the seed supply is essential. In both cases, the work should be judged not by the total area replaced or by the number of pounds of seed distributed but *by the percentage of the cotton crop replaced.* Once a large stretch of country grows nothing but the new kind, mixture of seed becomes more difficult and the control of the seed supply is simplified.

Wheat. The principal feature of the results obtained during the year, on the improvement of the Indian wheat crop, relates to the work in progress with Pusa 12 in the United Provinces. As stated in the last report, the trials of this wheat by the cultivators in all parts of these Provinces have been uniformly successful. During the past season, when the general wheat crop was attacked by rust and the yields proved to be below those anticipated, Pusa 12 again stood out markedly and gave a good yield even in the worst affected districts. These results have led to the adoption of a scheme under which the country wheats are being systematically replaced by Pusa 12 from certain centres so that large areas of the improved kind will be available to serve as a reserve of pure seed for the Province and also to supply the trade with the new wheat. This work is being conducted in the Central Circle in collaboration with Mr. B. C. Burt, Deputy Director of Agriculture, and during the past year a considerable amount of progress has been made. The rate at which the replacement can proceed depends on the volume of pure seed available. A considerable amount is grown by Mr. Burt at the new seed farm at Kalianpur near Cawnpore and this is supplemented by supplies from Bihar which vary a good deal with the season. During the past year, the work was hampered by shortness of seed but proposals have been made to increase the farm at Kalianpur and it is expected that, in future years, Bihar will be able to supply more seed. During the progress of the work in the Districts, it has been decided to send to England one or two shipments of Pusa 12 for trial by the Home millers so as to bring to the notice of the trade a new source of high quality wheat. The first parcel was sent to England this year with the help of Messrs. Ralli Brothers, who with Mr. Humphries have rendered valuable assistance to Government in bringing the wheat to the notice of the Home millers. One exceedingly satisfactory feature of this work is worthy of notice, namely, the instant appreciation, on the part of the cultivators, of the improved quality of the new kind. The wheat at once gained a premium in the local markets. Mr. Burt is dealing with this aspect of the matter in a paper which is now in the press.

Sugarcane. An increasing amount of attention is now being paid to the improvement of the sugarcane in India. While much of the work is

necessarily of a preliminary character, it is pleasing to record that several definite advances have been made during the year.

The new cane-breeding station at Madras, which has been referred to in previous reports, continues to make progress under Dr. Barber's direction. The land has been improved, a large number of new seedlings have been raised and studied in considerable detail. Some of these new canes are being tested outside the station in Madras and also at Shahjahanpur in the United Provinces. In several papers issued during the year, Dr. Barber has dealt with the Indian sugarcane crop as a whole as well as with the numerous problems and difficulties involved in its improvement. The thin, hardy canes of the Punjab have been studied and a systematic description of these interesting forms has been published in the Memoirs of the Department of Agriculture.

In Bihar, the results of a detailed study of the local canes has been published by Mr. Woodhouse and his colleagues. The canes have been grown in pure culture, classified and described and this valuable material should greatly simplify the work of the new sugarcane station in Bihar. A feature of this work is the broad connection which has been established between the botanical and chemical characters of many of the varieties.

From the point of view of immediate practical results in Northern India, the work of the new sugar station at Shahjahanpur is of the greatest promise. Mr. Clarke has now completed the equipment of the station as well as a preliminary study, both in the field and in the laboratory, of pure cultures of local as well as many other Indian and imported canes. So far, the best results, from all points of view, have been obtained with a Java seedling described as Java 33. This is a medium sized cane which ripens early, withstands the hot west winds of May and June and appears to be well suited for cultivation in many parts of the submontane sugar tract of the Indo-Gangetic alluvium. Besides the all important fact of a satisfactory tonnage of cane and of sugar to the acre, the juice has a high purity and its sucrose content is well above that of the local canes. One thousand maunds of cuttings were distributed to the cultivators and the crop is reported to be doing well. A much larger quantity of cuttings will be available this year and the progress of this variety in the plains will be a matter of considerable interest. Although this cane was obtained from Java, it is partly of Indian origin and is one of the new canes obtained by the Dutch investigators by crossing the thick Java varieties with hardy North Indian forms.

In the Central Provinces, Messrs. McGlashan and Clouston have published a paper of some interest. By extending the planting season and establishing the sugarcane crop in October on the late monsoon rains, greatly increased crops have been obtained and the early planted cane has been found to stand the hot weather much better than that planted at the ordinary time at the end of the cold season. These results will no doubt do much to stimulate the development of sugar production in the Central Provinces.

In Madras, Mr. Sampson has recorded some experiments on sugarcane growing in the South Canara District which are of more than local importance. Considerably improved yields have been obtained by paying attention to drainage in this tract. There is no doubt that efficient drainage is of the greatest importance to the well-being of the sugarcane crop in India as a whole and that a great deal of damage is now being done to the crop by waterlogging, particularly in many parts of Bihar and the submontane regions. The introduction of an improved cane like Java 33, combined with drainage, would probably do more than anything else to improve the production of sugar in Northern and North-Eastern India.

The aeration of the soil. During the year two papers (written independently of one another) dealing with the importance of gaseous interchange between the atmosphere and the soil, have appeared. The first in point of time was that of Mr. Hole on the *oecology of sal,* the second on *soil ventilation* was by the writer. In the development of *sal* seedlings in the forest and also in the case of many agricultural crops in India, want of sufficient air for the soil organisms and roots has been found to be a limiting factor in growth. The proper aeration of the soil is chiefly interfered with by excess of moisture either in the form of rain or as irrigation water. Unless the proper relations between air and water are maintained, it is found that growth slows down and finally a diseased condition results. Water, when it excludes air from the roots, soon acts as if it were a poison to plants. As soon as gaseous interchange between the soil and the air is interfered with, there is considerable evidence that the proportion of oxygen in the soil atmosphere falls while, at the same time, the carbon dioxide rapidly rises. If this condition continues, a slow poisoning of the plant begins and, after the cessation of growth takes place the foliage becomes yellow and unhealthy. The next stage is that of well-marked disease, often accompanied by invasion of the tissues by insects and fungi which are not unnaturally regarded as the causes of the trouble.

In the case of *sal,* Mr. Hole found that the fungus *Cercospora* was continually attacking and causing red brown spots on the leaves of seedlings both in the experimental garden and in the forest. The damage done was insignificant in the case of healthy vigorous plants but was far more extensive and serious in the case of weakly plants, growing in a badly aerated soil. When the fungus did damage it was obvious that it was rather the consequence than the cause of the disease. The real trouble was found to be interference with the air supply to the roots of the seedlings.

The writer has investigated in detail three similar diseases and, in all cases, want of aeration of the soil, rather than the various insects and fungi found on the diseased plants, was proved to be the real cause of the damage. At Quetta, many of the peach trees produce yellow, unhealthy foliage and such trees before their death are loaded with scale insects and also exude gum in large quantities besides exhibiting extensive decay in their roots. The trouble was found to be due to want of air in the soil and could be produced at will,

either by over irrigation or by deep planting. Green manuring with *shaftal*, (*Trifolium resupinatum*) to promote aeration, and the control of the water supply were found to be excellent remedies for diseased trees not too deeply planted.

At Pusa, the wilt disease of gram and of indigo has been traced to interference with the supply of air to the roots and root nodules. As soon as these crops were given suitable soils and when the air supply to the roots was regulated by suitable surface cultivation, the disease disappeared and normal growth and development ensued.

Two other cases of wilt in *sanai* (*Crotalaria juncea*) and in *patwa* (*Hibiscus cannabinus*) also appear to be due to want of aeration caused by heavy monsoon rain on a fine alluvial soil. Every year it is observed at Pusa that these crops grow well at first and are quite free from insect pests. As soon as waterlogging occurs towards the end of the monsoon, growth begins to fall off and various insects and fungoid pests appear which are often regarded as the causes of the trouble. In addition to these cases of so-called disease, a good many others have been observed, some of which are being investigated. There seems no doubt that the rôle of insects and fungi in the diseases of crops has been somewhat exaggerated and that a truer point of view is to regard these so-called pests as indications that the well-being of the crop is being interfered with by causes such as unfavourable conditions of growth, due to the soil or to the climate.

The practical applications of the results on soil ventilation are many and obvious. In some cases, as in indigo and gram, they have already been translated into practice. There seems little doubt that the future of the indigo industry in Bihar depends on the copious aeration of the soil in which this crop is grown. In the case of green-manuring in India, soil ventilation appears to be one of the chief factors on which success depends, while in tobacco cultivation in Bihar there is reason to believe that the cost of production can be materially reduced if means of permanently aerating the soil are adopted.

Perhaps the most important direction in which the air supply of the soil can be increased is by means of surface drainage. A method has been worked out at Pusa and is now in successful operation on several of the estates in Bihar. This consists in dividing up the area to be drained into areas from five to ten acres in extent by means of a set of trenches so devised that the surplus rain water is got rid of and, at the same time, soil erosion is prevented. On the Dholi estate, some remarkable results were obtained during the year. In one case, a large area, which previously gave little or no return on account of waterlogging, was so transformed in a single year by surface drainage that it was let out to ryots for chillies at a rent of ninety rupees a bigha to the manifest advantage, both of the cultivators and of the estate. In another case, a portion of the *zerat*, which had previously been rendered very infertile by scour, was let to tobacco growers for the first time at a rent of one hundred and forty rupees a bigha. Similar results have been obtained on other estates

and there is little doubt that this improvement, the capital cost of which is not more than two rupees a bigha, will spread rapidly in Bihar. To obtain the best results, however, it will be necessary to study the rivers in North Bihar in detail and to draw up proper drainage maps and working plans. This aspect of the subject has been dealt with in *Pusa Bulletin* 53. The full development of drainage in Bihar is now beyond the means of the Botanical Section at Pusa and can be realized only by the employment of engineers. Enough has been done however to show how much the production of Tirhoot can be improved by increasing the air supply in the soil by surface drainage. Bihar is now the waterlogged garden of India. Drainage would at least double its production.

Indigo. During the year, a considerable amount of progress was made in the indigo investigations at Pusa which has enabled definite recommendations to be placed before the planting community. A study of the so-called wilt disease, which has been responsible for the great diminution in area under Java indigo in Bihar in recent years, led to the realization of the important part played by the root nodules in the general economy of the plant and also in the production of indican. This in turn made it possible to perceive the factors on which the yield of indigo depends and to work out improved methods of production, both of indigo and of indigo seed.

Indigo wilt was found to be the last phase in a starvation process which always takes place in this crop when the work of the root nodules is seriously interrupted. Wilt may be produced in two quite different ways. In the first place, when indigo has been subjected to long continued wet weather, resulting in a waterlogged condition of the ground and in an insufficient supply of air for the roots and nodules, the plants cease to thrive, growth slows down and the characteristic unhealthy foliage associated with wilt is produced. Such plants die slowly without setting seed and when the wilted condition has been reached are found to have lost most of their nodules and feeding roots. In the second place, wilt is produced in healthy plants, growing in soil where there is plenty of air and moisture, when the nodules are suddenly deprived of their food supply. If rapidly growing Java indigo, sown in August for seed, is cut down to the ground in October most of the plants die and only a few make fresh growth. In the majority of cases, this new growth is wilted and such plants maintain themselves during the cold weather with the greatest difficulty. Examination of the roots soon after the cutting back shows that the nodules are in a moribund condition. These results enabled improved methods of cultivation and of seed-growing to be devised, which were immediately tried and found successful on the indigo estates themselves.

The secret of success in the cultivation and management of both Java and Sumatrana indigo has been found to be efficient surface cultivation in the hot weather, combined with drainage in the monsoon. The hot weather cultivation, for which suitable implements have been introduced into Bihar, enables the crop to obtain an ample air supply and also leads to the destruc-

tion of weeds and to a great saving in the cost of production. Surface drainage on the Pusa system, by preventing the flow of surplus rain water over the indigo fields, assists in maintaining the essential air supply to the roots and nodules and so tends to increase the growth and to prevent wilt. The adoption of these methods on the Dholi estate for the 1914 crop led to a record yield both of finished indigo and of *seeth*.

The discovery of the nature of the wilt disease also led to a method of growing the seed of Java indigo which is rapidly being taken up all over Bihar. Formerly, the old indigo crop was kept over the cold weather and seed was collected from these plants. This placed the planters at the mercy of the season as, in many cases, the crop became so weak from wilt that it produced only a small quantity of poor seed. At the same time, very large areas had to be set aside for seed which became very foul with weeds. The new method makes the planter independent of the season and leads to the certain production of well-grown seed from a comparatively small area which can easily be kept in a clean condition. For seed, Java indigo must be sown in early August in high-lying, well-drained fields which are in good condition. The plants must be well cultivated and properly spaced so that they branch, grow rapidly and come into flower towards the end of October. At this period the weather is warm and dry, bees are abundant and all the conditions for pollination are present. This method was adopted on the Dholi estate for the 1915 harvest when a very fine crop of seed of over eleven maunds to the acre was obtained. The land was afterwards kept through the hot weather and yielded crops of leaf in the ordinary way.

The provision of a better cover crop for Java indigo has enabled several estates in Bihar to reduce the cost of cultivation. A new variety of wheat, Pusa 4, has been introduced which can be grown with indigo on high lands. This wheat is a rapid grower, does not tiller much, has a strong straw and is provided with few leaves. On this account, the young indigo plants get a full supply of light and air and the two crops do very well together. It is hoped later on, when this new wheat spreads, to establish a grade for the Calcutta market.

Among the items of investigation now in progress with regard to indigo may be mentioned the selection work on Java and Sumatrana and the experiments devised to increase the efficiency of *seeth* as a manure. New varieties of Sumatrana and Java indigo are being tried this year on an estate scale and the results will be dealt with later. Evidence has been obtained that a part of the value of *seeth* in tobacco growing lies in its power of aerating the soil and of providing the soil organisms and the roots of the tobacco with an adequate supply of air. If this is confirmed, *seeth* can probably be made to go further by adding a suitable proportion of broken tiles (*thikara*) to the soil.

The progress that has already been made in the indigo investigations indicates that the prospects of resuscitating the industry are very favourable. The competition of the synthetic product has, for the time, been removed, a

period of high prices has set in which will be the means of establishing confidence and of putting the estates which are growing indigo into order. The value of the industry to Bihar agriculture is considerable. *Seeth* is an excellent manure and the part played by the Java plant in the rotation, in aerating the subsoil, is much greater than is commonly realized. Apart from all the other aspects of indigo growing, the industry is well worth saving from the point of view of the welfare of the people and of the maintenance of the fertility of the soil.

Gram. For some years a botanical study of the varieties of gram, cultivated in India, has been in progress at Pusa and a good deal of work has been done on the general requirements of this crop as regards soil and cultivation. As in Java indigo, the well-being of the crop depends to a very large extent on the physical condition of the soil and on a copious supply of air to the nodules and roots. The results obtained on different classes of soil in the Botanical area explain both the present geographical distribution of gram in India as well as the dependence on the season of the yield of seed. The two chief climatic conditions which limit the yield are heavy rains, which produce surface crusts and deprive the roots of air, and damp weather at flowering time which interferes with pollination. Self-pollination is the rule in gram at Pusa but instances of natural crossing occasionally occur. Twenty-five types, differing widely in habit and yielding power, have been isolated which are now being tested for yield under varying conditions. One interesting fact has already come out of these variety trials, namely, the union of high yield and good quality in the same variety. Type 9, grown at Pusa for the last four years on a large scale, on widely varying soils and in very different seasons, has given an average yield of just over twenty maunds per acre. This is the second highest average outturn, the best being that of twenty maunds thirty-three seers yielded by Type 18. Taking both yield and quality into consideration however and on the basis of the valuation of Messrs. Ralli Brothers, Type 9 gave the best return, an average of Rs. 78-11-0 per acre, while the average produce of Type 18, the highest yielder, was worth only Rs. 61-4-0 per acre. This result is another illustration of the value of selection methods in improving Indian crops in the present condition of agriculture in this country. Had an attempt been made by hybridization methods to achieve such a union of yielding power and grain quality, the work entailed would have been arduous and long continued.

Fibres. In 1910, a study of the varieties of *patwa* (*Hibiscus cannabinus*) was completed at Pusa when it was observed that one of the kinds, Type 3 appeared to be much more suitable for cultivation than any of the others. In the account of this work published in 1911 (*Mem. Dept. of Agr. in India, Botanical Series*, vol. IV, no. 2) mention was made of a possible method of keeping cultures of this type pure by removing heterozygotes in the seedling stage. If this could be done in practice, the difficulties with regard to vicinism in the case of a crop in which a good deal of natural crossing takes place, would be surmounted. Since that time, Type 3 has been grown from

unprotected seed and every year the plot has been rogued in the seedling stage and again before flowering commenced. In this way, all heterozygotes have been removed and the kind has been kept pure notwithstanding the many opportunities of crossing which occurred with the other types grown in the Botanical area. A pure seed supply having been obtained and the method of production having stood the test of time, steps were taken to work out the best way of retting and to obtain expert opinion on the produce as compared with the fibre produced locally. By cutting the plant at the proper time and retting it in clean river water, a very fine sample of fibre was produced which was submitted for opinion and valuation to Messrs. Wigglesworth & Co., 82, Fenchurch Street, London, E.C., who valued it at £18 per ton compared with £8 for the locally produced fibre. Messrs. Wigglesworth stated that the sample of Type 3 was " of excellent growth, being 10 to 12 feet long, exceptionally light coloured, correctly retted and thoroughly well-cleaned. Judging by the individual stalks, I should conclude that the yield of fibre must have been of quite exceptional weight. The fibre is pure from end to end and is free from root. It is also of good tensile strength and I have no hesitation in pronouncing it the best specimen of fibre from the *Hibiscus cannabinus* plant which has ever been submitted to me. This class of fibre could be sold in almost unlimited quantities."

Great stress was laid by Messrs. Wigglesworth in their report on correct and thorough retting and on the importance of this in connection with manufacture. Their valuation will serve to draw attention once more to the great increase in value of fibre, such as Deccan and *sann* hemp, which would immediately be obtained if more care were taken in retting and in placing the product on the market in the most suitable form. All this has been pointed out many times before but the fact that a carefully retted sample from India should have made such a favourable impression on the brokers proves how low is the present standard of preparing fibre in this country for the European manufacturers. Seed of Type 3 can now be obtained at Pusa and trials of this fibre on some of the estates in Bihar are being arranged.

At Dacca, Mr. Finlow has continued his work on the improvement by selection of the jute crop and some of the new kinds have been tried on a field scale during the past season. A Conference on jute was held at Calcutta during the past summer in which the future lines of work on this crop were considered. The report of the Conference was not available when the present manuscript was sent to the press.

Cinchona. The history of the resuscitation of the Cinchona industry has been dealt with by Major Gage, Superintendent of Cinchona Cultivation in Bengal, in the fifty-third annual report of the Government Chinchona Plantations and Factory in Bengal. At the beginning of the present century, the plantations were in a very unsatisfactory condition, the yield of bark was low, the quinine content poor and the extraction efficiency of the factory was only 70 to 75 per cent. of the possible. It is hardly necessary to say that under

such conditions the cost of production was high and a reserve of quinine was out of the question. The work of improvement was commenced by Major Prain about 1900 but the progress was hampered by the absence of a quinologist whose appointment was suggested in 1904. In 1905, Major Gage became Superintendent of Cinchona cultivation when the conditions were as follows — on Mungpoo there were 1,350 acres of cinchona yielding 272lb. of bark per acre per annum, the bark containing only 2·5 per cent. of quinine; on Munsong there were only 387 acres of immature cinchona; the possible factory output was only 14,000 lb. of quinine to which the plantations could contribute less than 9,000lb., the extraction of the factory was low, quinine cost nine rupees a pound and there was no reserve. In 1905, the work of renovating quinine production was taken in hand and a quinologist was appointed. All the poor, badly-grown cinchona was cut down, improved methods of cultivation were started and seed selection, on the basis of analysis of the parent trees, was taken up systematically. While the area under the improved cinchona trees was expanding, the factory was developed so that over 50,000 lb. of quinine could be produced every year. Ten years have passed since these operations were commenced and the position to-day can only be described as exceedingly creditable to all concerned. The area under cinchona has risen from 1,737 to 2,552 acres, the yield of bark has increased from 272 to 330lb. per acre, the average quinine percentage has almost doubled and the factory output has increased from 14,000 to over 50,000 lb. of quinine, the extraction efficiency has been raised from 75 to 95 per cent. while the cost of production has been lowered nearly half. A reserve of 163,000 pounds of quinine has been built up and the whole production has been placed on a satisfactory basis.

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Part II.—Forest Botany

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Oecology of Sal (*Shorea robusta*).—The first stage of the experiments dealing with this subject which have been in progress for some years having

been completed during the year, it is now advisable to briefly review the principal results obtained. The principal object of the work was to discover a remedy for the widespread death and dying-back of seedlings responsible for the failure, partial or complete, of natural reproduction in the Sal forests of northern India.

Chief factors responsible for failure of Sal reproduction.—The work which has been carried out at Dehra Dun during the last few years has shown that although sal seedlings in this locality have to face many dangers, such as wholesale destruction of the seed by porcupines, injury to the shoot and leaves by deer, insects and leaf-fungi and damage to the root by insects, these factors are of minor importance. Frost undoubtedly does great damage in open grasslands but, apart from altogether exceptional seasons such as the cold weather of 1904-05, does very little damage in the sal forests themselves. On the other hand, the two factors noted below have been found to be of outstanding and primary importance:

(*1*) *An injurious soil factor* which comes into operation in the rainy season, especially in the months July and August. So far as is known at present, this factor can be effectually put out of action by sufficiently good soil-aeration and for the present it may be conveniently termed *bad soil-aeration*.

(*2*) *Drought* which causes widespread damage during the season of short rainfall from September to June.

Of these factors No. (1) is the most important, seeing that those plants which show vigorous and thoroughly healthy development throughout the rains are, as a rule, well able to withstand the subsequent danger of drought, owing to their strong deep-going root-system, whereas those plants quickly succumb which are weakly and have poorly developed roots at the close of the rains. It is, therefore, of the utmost importance to see that seedlings develop during the rainy season under conditions as nearly ideal as possible and this, as a rule, is all that is necessary for success.

Chief Facts regarding Bad Soil-Aeration.—As regards the soil factor No. (1), the work done up to date has not sufficed to define its precise nature or the exact way in which good aeration renders it inoperative. The chief facts ascertained regarding it are summarised below:—

(1) It has been proved that, in the local sal-forest loam, the injurious factor suffices to kill or seriously damage 100% of sal seedlings when, through bad drainage, the soil near the roots contains a high percentage of water and a small volume of air-space, whereas in the same soil, when well drained, with less water and a larger air-space, the injurious factor is practically inoperative.

(2) It has been shown that, on one and the same type of soil, whereas the injurious factor has accounted for 95 to 99 % of casual-

ties among sal seedlings inside the shady sal forest, in two widely separate localities and during two consecutive seasons, it has had very little effect on the same soil in the open. The surface soil in the shade, also, has invariably contained a higher percentage of organic matter and water and smaller volume of air-space than the same soil in the open.

(3) The injurious factor depends to a great extent on the presence of organic matter (especially dead sal leaves). Thus experiments have proved that its injurious effect can be greatly increased by mixing dead sal leaves with the surface soil, while, on the other hand, its effect can be gradually neutralised by merely keeping the surface soil exposed to the air and clear of dead sal leaves.

(4) The injurious factor is inoperative in a well-drained sand containing 7 % of calcium carbonate, even when dead sal leaves are mixed with the soil.

(5) Experiment has shown that the injurious factor may be operative in soil A and not in soil B, although both soils are of the same type (*i.e.*, the ordinary loam characteristic of the local sal forests) and the conditions of aeration slightly more favourable in A (as judged by the percentages of water and organic matter and the volume of air-space), provided that the surface of soil B has been kept clear of dead sal leaves and exposed to the air for a longer period than has that of soil A.

(6) Sal seedlings have been grown successfully, under artificial shades, in the loam of the Dehra Dun experimental garden which, during the rains, contained more water and less air-space than a similar soil in the local forests in which sal seedlings succumbed to the injurious factor. The garden loam, however, contained 2—3 % less organic matter than the forest soil.

(7) The evidence at present available indicates that the injurious factor is not correlated with a deficiency of essential plant food such as nitrates.

(8) Throughout the experimental cultures it has been repeatedly noticed that the injurious factor tends to assert itself during the rains, especially in the lowest parts of the seed-beds where water tends to accumulate and in those areas where the surface soil has formed a crust under the impact of heavy rain which interferes with the access of air and water into the soil; also that in different soils, other things equal (especially the content of organic matter), its effect tends to be most injurious in those which show the slowest rate of surface percolation. With regard to this point, weeding during the rains is especially beneficial as it tends to break up the surface and improve soil-aeration.

Effects of Bad Aeration.—None of the facts detailed in the last paragraph controvert the statement that the injurious factor can be rendered innocuous by sufficiently good soil aeration. At the same time points serial Nos. 3, 5 and 6 clearly show that its existence to a great extent depends on the presence of organic matter. On the whole it seems probable that :

(1) the injurious action is due partly to lack of sufficient oxygen for root-respiration and partly to the existence of one or more toxic substances in the soil which are directly poisonous to the roots

(2) the toxic substance or substances possibly are in part excreted by the plant-roots themselves or by some of the numerous soil organisms, but they are probably chiefly produced as a result of the decomposition of the organic matter in the soil

(3) the toxic substance or substances can accumulate and become injurious only under conditions of bad aeration coupled with a high water-content, whereas they are rapidly dissipated and rendered innocuous by good aeration.

Remedies for Bad Sal Reproduction.—Fortunately it is often possible to discover a practical remedy for a particular factor, the precise nature of which is not fully understood and so far as the chief object of the present work is concerned, *viz.*, the discovery of a remedy for the failure of sal reproduction, the experiments have clearly shown that ideal development of sal seedlings, without dying back, can be secured in the local sal forests by clear felling in strips or patches, combined with artificial sowing and weeding during the first rains. The work done has also shown that the ideal conditions for the development of sal seedlings on the loam characteristic of the local sal forests are : (1) a well-aerated seed-bed free of raw humus ; (2) full overhead light ; (3) light side-shade sufficient to prevent damage from frost and to keep the soil as moist as possible during the season of short rainfall.

So far as can be seen at present, these conditions are best provided by the system of clear-felling in narrow strips and small patches. At the same time the method which produces the best growth is not always the best sylviculturally. Thus it is possible that the results obtained, excellent though they may be, do not yield a sufficient return to justify the high expenditure required, or the method may require more labour than is locally available. Such considerations may render clear-felling impossible, except locally in limited areas. The experiments carried out, however, indicate an alternative method of aiding the establishment of reproduction *viz.*, by the continued removal of humus and dead leaves by light leaf-fires or otherwise. In this way the number of sal seedlings on the ground can be materially and quickly increased. Their growth is decidedly inferior to that of seedlings established in the open but it is probable that early removal or opening of the cover may soon remedy this defect.

Drought the chief factor in forests of the Dry Type.—The above remarks apply to the better class of sal forests belonging to what may be called the moist type and in them the soil-aeration is the dominant factor. In sal forests of the dry type, on the other hand, a deficiency of soil moisture, leading to extensive damage by drought, is the primary factor. Improvement should here aim at increasing the soil moisture-content (1) by maintaining the cover and introducing an underwood where necessary, (2) by increasing the admixture of humus in the soil, (3) by preventing the run-off of rain-water and encouraging its percolation into the soil by trenching, small embankments or surface cultivation and (4) by preventing evaporation in the dry season by surface-cultivation and mulching. The fact noted in previous reports that the dominant grasses are excellent indicators of the soil conditions is of considerable practical value in determining the type of any particular forest and the treatment likely to be most successful in it. During the year, the Botanist visited the Jaspur sal forests of the United Provinces, at the request of the local Conservator, for the purpose of giving advice as to the treatment most likely to secure their successful reproduction.

Trametes Pini.—A paper giving the results of this inquiry up to date was published during the year. The principal object of the work was to determine how far infection spread through the roots of *Pinus excelsa* and the best practical method of controlling the fungus. It has been ascertained that the fungus is spread chiefly through wounds in the stem by wind-carried spores and is best controlled by prohibiting all lopping of the pine.

Systematic Botany.—The Indian material of the genera *Xylia* and *Iseilema* available at Kew and the British Museum was studied by the Botanist during the year. A new species of forest grass (*Spodiopogon Lacei*) was discovered and published during the year.

Local forest floras.—The preparation of Descriptive Lists or Local Floras is in progress in the Punjab, United Provinces, Central Provinces, Madras, Coorg, Bengal, Assam, Burma and the Andamans. Mr. Haines and Mr. Witt have completed the 2 lists for the Central Provinces and these are now in the Press. Mr. Parker has completed the manuscript of his Forest Flora of the Punjab. Mr. E. M. Crothers, Extra Assistant Conservator of Forests, has also prepared a preliminary list of trees and shrubs in South Coorg which is now in the Press. During the year, 1,801 plants were identified for forest officers and others by the Forest Botanist and his Assistant Mr. G. H. Alington. This is by far the largest number of identifications yet carried out at Dehra Dun in any one year. The next highest figure is 1,226 attained in 1913-14. These figures give some indication of the value of the Dehra Dun herbarium to the Forest Department.

List of Publications.

ANONYMOUS . . Fungi and Plant Diseases. (*Ind. For., xli, p. 1.*)

BRADLEY, J. W.. .	Flowering of Kyathaung Bamboo (*Bambusa polymorpha*) in the Prome Division, Burma. (*Ind. For., xl, p. 526.*)
BUTTERWORTH, G. S. .	The Tali-pot Palm (*Corypha umbraculifera*). (*Ind. For., xli, p. 3.*)
CANNING, F. . .	Twisted Fibres in Chir Pine. (*Ind. For., xli, p. 112.*)
HAINES, H. H. . .	List of Trees, Shrubs and Economic Herbs of the Southern Forest Circle of the Central Provinces. (*Ind. For., xl, pp. 330, 392, 429, 472.*)
HOLE, R. S. . .	Development of the Culms of Grasses. (*Forest Bulletin 25 (1914).*)
,, . . .	Oecology of Sal. (*Forest Records, v, pt. 4.*)
,, . . .	*Trametes Pini* in India. (*For. Rec., v, pt. 5.*)
,, . . .	A new species of Forest Grass. (*For. Rec., v, pt. 6.*)
LUSHINGTON, A. W. .	Vernacular names of trees, shrubs and climbers in Madras Presidency.
PARKER, R. N. . .	New Indian Species of Forest Importance. (*Ind. For., xl, p. 404.*)
RAMASWAMI, M. S. .	A new species of *Diospyros* from the Tinnevelly Hills. (*Journ. As. Soc. Beng., x, p. 47.*)
SMYTHIES, E. A. . .	Notes on the twisted fibre in Chir Pine. (*Ind. For., xli, p. 69.*)
TROUP, R. S. . .	*Peridermium Cedri* as a destructive fungus. (*Ind. For., xl, p. 469.*)

BOTANY

MYCOLOGY.

BY

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Agricultural Research Institute, Pusa.—The following plant diseases were investigated during the year :—

(1) **Paddy.**—The work on "ufra", the nature of which was described in the last annual report, was continued and experiments were conducted at Comilla and at Pusa with a view to the discovery of some remedial measure. Owing to a deficiency of water in the experimental area at Comilla this work did not give any conclusive results. The experiment is being repeated this year with additional precautions.

Working with small plots at Pusa it was found that the disease could lie dormant in the soil and infect a new crop. Cutting the diseased crop and burning it *in situ*, with a little kerosene, prevented the infection of a succeeding crop. It is unsafe, however, to generalise from a small experiment such as this ; it is possible to subject a small area to a much more thorough burning than would be practicable on a field scale.

The infected area in Eastern Bengal appears to be much the same as last year and the disease has been again reported in the vicinity of Ranchi, in Bihar and Orissa where it is said to occur on transplanted paddy and not upon the early broadcast.

A diseased condition of the paddy crop in Balasore and on the Government Farm at Bankipore was investigated but "ufra" was not found ; at Balasore drought appeared to be the cause of the trouble but at Bankipore the condition was said by local officers to be that known as "chatra"; however no trace of a parasite could be found.

"Gwa-bo"—a disease which is the cause of extensive damage in Burma was investigated without any very definite result. In some areas about 50 per cent. of the disease appears to be due to *Sclerotium Oryzæ* Catt. (*vide* Memoirs of the Department of Agriculture in India, Botanical Series, Vol. VI, No. 2, July, 1913) but it is almost certain that the diseased condition is the result of the combination of a number of adverse factors and is not due to the attack of any single parasite. In particular some insects appear to be responsible for a large amount of the disease.

(2) **Tobacco.**—Field experiments with "tokra" of tobacco were commenced and yielded some results of scientific interest. *Orobanche cernua* Loefl. and *Orobanche indica* Buch., both occur on tobacco but *O. cernua* is much the more serious parasite of tobacco and solanaceous crops generally, while *O. indica* is a source of heavy damage to *Cruciferæ* (*e.g.*, mustard, cabbage). A good crop of tobacco was raised on a field which had been under cabbages in the previous season and which was known to be infected with *O. indica*. Further experiments to test the effect of different chemical manures on the incidence of "tokra" are in progress.

(3) **Rubber (Hevea).**—At the request of the Director of Agriculture, Burma, the section undertook the investigation of a disease of *Hevea*, called "black thread," in Lower Burma. The disease is characterised by the appearance of longitudinal black lines in the naked tissue immediately above the tapping cut. These black lines mark areas of disintegration, stretching through the cambium into the wood, and as tapping proceeds they follow the fresh cut down the stem. The flow of latex becomes decreased but the most serious aspect of the disease is the failure of an infected tree to regenerate the bark over the tapped area.

Microscopic examination of the black cracks has up to the present failed to demonstrate the presence of any fungus parasite, but in the bark immediately adjoining the infected area hyphæ of a fungus often occurred. This fungus was identified as *Phytophthora*—the cause of the "canker" of Hevea. At the moment of writing the investigation has not been carried further but experiments are in progress.*

(4) **Sal tree (Shorea robusta).**—At the request of the Bengal Forest Department the section undertook the investigation of a disease in the *sal* forests of the Duars, said to be due to a fungus parasite. In the Buxa Division a considerable number of *sal* trees can be seen in a dead and dying condition. When dead the trees are left standing bare and leafless and in dying trees the foliage is scanty and there are obvious indications of a decrease in vigour of growth. In all the dead and dying trees which were examined there were indications of a fungus attack in the roots. If the main root of an unhealthy tree is laid bear to a depth of about three feet and the outer corky tissues are cut away with a knife it is found that most of the phlœm has been destroyed leaving nothing but the bast fibres; in the disintegrated tissue between the strands of fibres white rhizomorphs occur and a fungus mycelium is everywhere common. In dead and badly affected trees this condition is found to extend up the trunks sometimes as much as two feet above the soil. In such cases a fructification of a bracket fungus (probably *Fomes*) is often found on the stem. In every case examined in which this fructification was present the phlœm showed the diseased condition described above. Thus while all unhealthy trees show a diseased condition of the phlœm with the

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* Inoculations with a species of Phytophthora isolated from the diseased rubber trees have been successful in reproducing the disease.

presence of a mycelium with rhizomorphs, the most advanced cases of disease also bear a sporophore. From field observations therefore there is a strong presumption that the disease is due to the attack of a basidiomycete of the genus *Fomes*; the fact that this fungus is one of a group which is responsible for most diseases of timber strengthens the evidence and moreover the presence of rhizomorphs in the diseased phlœm is what would be expected in association with a *Fomes* fructification on the exterior of the trunk.

The fungus has been obtained in pure culture and will be tested by inoculations. While it is not unlikely that the fungus is the direct source of damage it will probably be found that the conditions under which the *sal* trees are living are such as favour the presence of a fungus parasite and decrease the vitality of the *sal* tree. When the factors which are necessary for the fungus to gain an entrance into a healthy *sal* tree are known it may be possible to control the disease by altering the hygienic conditions under which the trees live and thus lessening the chances of a successful infection. It is improbable that it will be possible to apply any remedial measures in dense jungle such as occurs in Buxa; treatment might, however, be possible in the case of plantations.

(5) **Rhizoctonia.**—Work on this fungus was continued and the results are being published as a memoir of the Department. The species *R. Napi* West was found to be a dangerous parasite of mustard and gram. This fungus is incapable of active growth at temperatures above 29°C—a circumstance which limits its depredations in India. A fertile stage was discovered and found to be identical with the well known *Botrytis cinerea* Pers., which was described as a disease of mustard by Frank some forty years ago. As a result of this it is considered that *R. Napi* is not a true member of the genus *Rhizoctonia*, which should be restricted to those species with a fertile stage in the genus *Corticium*. The species *R. destruens* Tass. was found to be the cause of serious disease of betel vine and potato in Lower Bengal, Bihar and parts of Bombay. In the latter province it also occurred on suran, lucerne and groundnut. There were some indications that the fungus had a perfect stage in the genus *Corticium* but no satisfactory proof could be obtained. Experiments suggested that corrosive sublimate was a more reliable fungicide against *Rhizoctonia* than formalin or copper sulphate.

In continuation of the research into the blight of opium poppy experiments were conducted with a view to discovering whether *Rhizoctonia* or *Peronospora* was the chief cause of this disease. Poppy was grown at Pusa from seed supplied by the Opium Department and the resulting crop became infected with *P. arborescens*. This fungus was also very plentiful on poppy in the vicinity of Ghaz.pur, but at Patiali *Rhizoctonia*, and not *Peronospora* was found. The matter cannot be regarded as definitely settled, but it is probable that *Rhizoctonia* is only a serious parasite of poppy when conditions such as poor soil or defective drainage are inimical to the growth of the crop.

(6) **Anthracnose.**—The investigation into anthracnose of betel vine in Khasi and Jaintia Hills did not yield any results of practical importance.

There is no doubt, however, that the perfect stage of this *Collectotrichum* is an ascomycete belonging to the genus *Glomerella*. Attempts to secure successful inoculations failed and our knowledge of this disease is therefore not in so good a position as it appeared to be last year. The well known anthracnose of chillies appears to be the cause of a good deal of trouble in the chilli growing districts of Burma and some form of treatment may be necessary.

Miscellaneous.—A certain amount of work was done on the fungi of Pusa soil. The chief interest of this preliminary investigation was the striking similarity between the fungus flora of an Indian soil and that which occurs in Europe. The species isolated in Pusa were *Cunninghamella elegans, Aspergillus fumigatus, A. niger, Rhizoctonia Napi*, of which the first three are all known in the soil in Europe. The fungus which causes "red-rot" of sugarcane was found to be parasitic upon juar under laboratory conditions but so far is not known to cause serious damage to this crop in the field. A rot of bananas was examined by the First Assistant and found to be due to a parasitic *Fusarium*. A preliminary account has been published in the Agricultural Journal of India; it appears that the disease is distinct from the well known Panama disease of bananas. The results of some observations on potato blight in India have been published as a memoir of the Department, the chief point of practical importance is the fact that the fungus cannot survive in the heat of the plains. Mr. Dastur has also continued his work on *Phytophthora* with the study of some forms parasitic in *Vinca*. It is hoped to publish results shortly.

Some preliminary work on the disease of chillies at Peshawar indicated that the disease was of the type known as "wilt." Inoculations with a fungus isolated from diseased plants were not successful and this year the incidence of the disease is much less. Treatment of oat smut with formalin on certain estates in Bihar was as usual completely successful.

Provincial Departments of Agriculture.—The following are the chief items of mycological work carried out by Provincial Departments of Agriculture during the year.

(1) **Assam.**—The investigation into anthracnose of betel vine was the only mycological work carried out in this province. It has been already dealt with in this report.

(2) **Bengal.**—The work on the ufra disease of paddy has been described above and is being continued this year on the lines indicated. A disease of betel vine in Bogra due to the attack of *Rhizoctonia destruens* Tass. was investigated in Pusa, the results are contained in a memoir now in the press.

(3) **Bihar and Orissa.**—The parasitism of *Rhizoctonia* on certain crops, *e.g.*, mustard, gram, potato, was investigated at Pusa. The "tokra" disease of tobacco was also studied and work on this is being continued.

(4) **Bombay.**—The Professor of Mycology, Poona, collaborated with the Officiating Imperial Mycologist in the work on *Rhizoctonia*, as this fungus is a

serious parasite of betel vine, suran and potato in the Bombay Presidency. The results of this work are now in the press. Experiments on smut and red-rot of sugarcane and demonstrations on the treatment of smut of jowar were carried out. The latter disease can be prevented by steeping the seed in copper sulphate—the cost working out at about three pies per acre. Spraying against grape vine mildew was continued with marked success as in the past year and the Department made some progress with the collection and identification of the fungi indigenous in Bombay.

(5) **Central Provinces.**—The principal mycological work done in the Central Provinces has been in connection with the breeding of rust resistant wheats and the introduction of wilt resistant varieties of cotton. Buri cotton is wilt resistant and endeavours are being made to select a resistant strain from the indigenous cottons growing in wilt infested areas. Measures are being taken to reduce the red rot in sugarcane by set selection and the smut of jowar by the distribution of copper sulphate as a seed steep.

(6) **Madras.**—The bud rot of palmyra palms continues to absorb a large part of the energy of the department. By means of a more thorough system of examining the palms the disease has been discovered in its earliest stages; in all some 127,000 palms were examined and about 9,000 cases of disease discovered. About 34,000 infected trees were operated on, of which less than 1,000 died subsequently.

The work on bud rot of coconut palms was continued and confirmed the results which were published last year; the disease is primarily due to the *Pythium palmivorum* Butl. and not to the attack of a coliform bacillus as is stated in the West Indies. The latter may play some part in the latter stages of the disease when, however, large numbers of saprophytic organism are also present in the decaying buds.

The spraying of areca-nuts against koleroga was continued with marked success and garden owners are taking up this work at their own expense.

A parasitic fungus on paddy, a fruit rot of chillies due to *Vermicularia capsici* Syd., and a disease of coconut palms are under investigation.

(7) **United Provinces.**—Experiments on the storage of potatoes were carried out. This subject has also been dealt with at Pusa (*vide* Memoirs of the Department of Agriculture in India, Botanical Series, Vol. VII, No. 4, 1915).

The opium poppy blight has been already discussed in this report (*vide Rhizoctonia*).

(8) **Mysore.**—Work has been done on the koleroga of coffee which appears to be due to *Hypochnus koleroga*. A bulletin is in course of preparation. Other investigations are in progress on the genus *Phytophthora*, the fungi parasitic on green scale *Lecanium viride*, and on *Fomes lucidus* on the areca-nut palm.

(9) **Indian Tea Association.**—Research upon the root diseases of tea and on the spraying of tea bushes formed the principal work of the mycological section.

List of Publications.

Annual Reports of Agricultural Research Institute, Pusa, and of Provincial Departments of Agriculture.

BUTLER, E. J. . . Cultivation of rice in Spain and the Recent International Rice Congress at Valencia. (*Agric. Journ. India, ix, Part 4, Oct. 1914.*)

DASTUR, J. F. . . Potato Blight in India. (*Mem. Dept. Agric. India, Bot. Ser. vii, No. 3, April, 1915.*)

CHIBBER, H. M. . . List of diseases of Economic Plants occurring in Bombay Presidency. (*Bull. 65 of 1914 of the Dept. of Agric., Bombay.*)

SHAW, F. J. F. . . Report on Mycology, 1914, for Board of Scientific Advice.

AGRICULTURAL BACTERIOLOGY.

BY

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WORK AT PUSA.

Bacterio-toxins in soils.—The work on bacterio-toxins in soils was continued and carried a stage further; it was found that the inhibition of nitrification occurring in soils under waterlogged or semi-anærobic conditions was not due merely to lack of the oxygen required for formation of the completely oxidized product, but to the action of toxins resulting from the activity of certain classes of bacteria which rapidly multiply under these conditions. That this toxic action was not due either to ammonia or carbon dioxide in excess was shown by the inhibitory action of water extracts of the toxic soils upon nitrification in normally ærated soil, and more conclusively by that of certain bacteria isolated from such soils, notably of one bacillus (Bacillus X), the toxic action of which was found to be sufficient to interfere with the growth and activity of all other soil bacteria brought in contact with it or with its separated toxin in culture.

It was found that such toxins result from the decomposition of organic nitrogen compounds by bacterial action under semi-anærobic conditions, and further proof that the inhibition of nitrification is not due merely to shortage of oxygen was afforded by the observation that, with the same air supply as was sufficient for complete nitrification of ammonium sulphate in soil, nitrification of oilcake containing the same amount of nitrogen was completely inhibited, nor did it commence when complete æration was provided, until after the lapse of a considerable period (generally about two weeks although this varied with different soils) when the toxins formed had had time to become destroyed by oxidation, after which normal nitrification ensued. It was found by the Imperial Agriculturist in actual practice in the field on the Pusa estate that germination in the soil which had been waterlogged was interfered with, and that the ensuing crop was consequently poor, nor was this remedied by application of nitrate of soda, although the use of super-phosphate was successful. Laboratory experiments showed that rapid reduction of nitrate takes place in waterlogged soil, a large proportion of nitrite being formed, and it seems probable that the toxins produced during the waterlogged period would not only affect the germination and the growth of the seedlings but that the character of the soil complex resulting from the semi-anærobic conditions which obtained at that time would be such as not only to interfere with nitri-

fication but to promote reduction for just so long as this abnormal character persisted. The character of the soil complex and that of the decomposition products of organic matter resulting from its action must vary with alterations in moisture and oxygen content of the soil itself, and it is probable that the altered character may persist for some time after the special conditions which gave rise to it have disappeared. This point is under experimental observation. It was found in the laboratory that superphosphate had a neutralizing action upon the toxicity to bacteria of extracts of certain soils and this was traced to the free acid ; this result, however, was not sufficiently conclusive to allow of its use as a convincing explanation of the favourable action of superphosphate upon waterlogged soils, although this theory is supported by Meggitt's work in Assam, but will require further experimental investigation.

Ammonification proceeded at the normal rate in soil under semi-anærobic conditions and was apparently not interfered with by the bacterio-toxins produced, although the activity of such ammonifiers as B. Mycoides is actually lowered by the presence of Bacillus X. ; this latter organism does not appear to be universally present in soils ; no concentration of ammonia above that in the ærated control was found nor was this gas given off by the anærobic soil. The action of carbon dioxide in excess was eliminated by absorption with potash, as well as by the use of the soil extract as mentioned above.

A special experiment was made to test the action of the carbon dioxide formed in soil by bacterial action, upon nitrification in that soil ; under partially anærobic conditions absorption of the carbon dioxide produced no effect upon nitrification in soil, either of oilcake or of ammonium sulphate ; in this experiment the observation was repeated that complete nitrification of ammonium sulphate took place under semi-anærobic conditions in which no nitrification of oilcake occurred.

It appears therefore that in soils in which æration is incomplete, as a consequence either of want of proper cultivation or of drainage, the decomposition of organic matter by such bacteria as thrive under these conditions will result in the production of toxins inhibitory of nitrification. It has also been shown that these toxins are destroyed by exposure to air and can be removed in water-solution, so that the ordinary operations of tillage and drainage can prevent their accumulation.

Work with seedlings (wheat, oats, rice, indigo, maize, dhaincha, jowar), has shown that in high concentration, such as occurs in waterlogged soils containing much organic matter, these toxins may directly affect growing plants especially seedlings, but this is an exceptional condition, whereas it appears probable that in normal fully ærated soils the toxins resulting from the ordinary metabolic activity of soil bacteria are oxidized at about the same rate as they are produced and no accumulation takes place. A very slight interference with the oxygen supply to the soil, however, will turn the scale in favour of accumulation of toxins and in consequence upset the natural equilibrium existing in the soil complex between the toxin sensitive nitrifying

organisms on the one hand and the apparently less easily affected reducing organisms on the other, thus resulting in indirect injury to the crop by interference with supply of nitrogen as nitrate. In soil which has been flooded during the monsoon the toxins formed may persist long enough seriously to prejudice the growth of seedlings if planted too soon; such soil should be given as long a period of æration as is possible before planting.

In order to ascertain the conditions under which such bacterio-toxins are produced in soils a great deal of work was carried out in isolating and determining the specific functions of soil bacteria, but the proper development of this line of enquiry would necessitate collaboration with a chemical specialist. The possible bacterial origin of the various organic compounds of a toxic nature which have been isolated from soils by such workers as Schreiner, Shorey, Skinner, Reid and others would be one of the problems involved. It was found that salts of some of the heavy metals such as copper had a decided influence in neutralizing the toxic action towards seedlings of extracts of soils kept under anærobic conditions; precipitation of the copper as sulphide was prevented by the addition of potassium cyanide, these salts being present in very small quantities; (0·025—0·03 per cent. $CuSO_4$). It appears probable that the discrepancies recorded between the observations of some workers upon the stimulating effect of such salts upon nitrification may be explained by reference to the fact that the cases in which contradictory results were reported were not comparable owing to the use of organic nitrogenous matter, from which toxins could have arisen, in one series, and ammonium sulphate in another.

An interesting case occurred in the field at Pusa in which the use of copper sulphate as a precautionary measure against attack by wire worms, resulted in a large increase on the treated plot as compared with an untreated control although both were free from attack by wire worm.

The toxic action of nitrites upon growing plants was demonstrated both under sterile and ordinary conditions in water cultures.

Nitrification.—Numerous experiments on nitrification in soils and solutions were carried out and much valuable information on the subject obtained. This was specially the case in connection with biological analyses of soils from various parts of the country, carried out for the most part by Assistants of Provincial Agricultural Chemists undergoing training in this section. Mr. Barkat Ali, Assistant to the Agricultural Chemist to the Government of the Punjab made a valuable biological analysis of Reh soils from that province, showing that although such bacterial activities as are essential to nitrification are practically non-existent in Reh soils, this condition is completely altered by washing out the excess of salt. Mr. D. V. Bal, Assistant to the Agricultural Chemist to the Government of Central Provinces tested the nitrifying power and capacity of certain soils from Sind which had undergone differential treatment in the field; this was found to vary considerably as a consequence of treatment. Interesting differences in comparative immunity shown by the

nitrifiers in these soils to the inhibitory effect of partial anærobic conditions as compared with the nitrifying agents in Pusa soil were observed, nor was the addition of lime beneficial in this respect. Nitrification in tea soils from different districts was studied by Mr. A. K. Ghose, Assistant to the Scientific Officer to the Indian Tea Association ; here very marked differences in nitrifying power between different soils, were found with varying results from the application of lime, and varying optima for water. Further experience with the method of biological analysis of soils has shown its value in elucidating soil problems and has made it possible to reduce it to a simple set of concurrent experiments.

The observed influence of toxins upon nitrification has been referred to above.

Nitrate formation in field plots under different crops has been under observation ; grass has been found entirely to prevent accumulation of nitrate in the soil in which it is growing ; this would have some bearing upon the action of grasses upon fruit trees, as the absence of nitrates must mean either that nitrification is inhibited or that the grasses take up the nitrate as rapidly as it is formed, or that in grassed soil reduction takes place at least as rapidly as oxidation.

The effect of various trees upon nitrification due to the fall of their leaves upon the ground was studied and considerable differences were observed.

The optimum amount of organic matter as oilcake containing 5 per cent. nitrogen for nitrification in Pusa soil was found to be about 1 per cent. of soil weight. At a concentration of 2 per cent., ammonia formation was so rapid as to result not only in inhibition of nitrification but in loss of nitrogen as ammonia gas ; the free ammonia also brought organic matter into solution and made it necessary to abandon the use of the tintometer for estimation of nitrates and to use the aluminium reduction method which was found more convenient and reliable for this particular purpose than the zinc copper couple. Indications were obtained that the prejudicial effect of organic matter upon nitrification is in many cases due to the rapid multiplication of toxin-producing bacteria consequent on its presence.

The effect of temperature on nitrification in Pusa soil was tested, the optimum being found to be near 35° C ; no nitrate was formed at 40° C., nor did nitrification take place in soil which had been kept at 40° C. when its temperature was afterwards reduced to 30° C.; further work on this point is being carried out to determine the cause of this apparent lowering of the thermal death point.

A series of experiments was carried out to determine if possible for what reasons on adding as solids such bacterial foodstuffs as oilcake or sugars to a live soil, the evolution of carbon dioxide resulting from bacterial action should rise in rate for a few days but fall again rapidly to a minimum long before exhaustion of the food supplied could be called upon to account for such dimi-

nution in activity. Reasons were found for thinking that this result, invariably obtained when solid nutrients were added to soil, was due in part to auto-intoxication by the soil bacteria, and in part to the purely physical facts of the case, depending upon the ratio between the superficies and the cubic contents of the particles of organic matter involved, and the possible protection against solution by bacterial enzymes afforded by the superficial layer of altered material resulting from their first attack. This argument was strengthened by the observation that in nutrient solutions the fall in rate of evolution of carbon dioxide is much less sudden than where solid particles are concerned. The rate of formation of carbon dioxide is materially affected by the size of particles supplied. Partial sterilization of the soil sufficient to eliminate protozoa does not remove this difference.

Green Manuring. – Owing to the difficulty of obtaining even areas of land for field experiments on the farm, it was arranged to take in a comparatively small area of one acre adjoining the outside laboratory of this section; this was divided into 24 plots of equal size and experiments in triplicate laid out for the "*kharif*" and "*rabi*" crops of 1914-15; the first was merely a crop of Sannai (*Crotalaria juncea*) over the whole area; this was applied as green manure, variations in the method of application and their effect upon the succeeding *rabi* crops, oats and tobacco, being studied. As was expected, however, unevenness in this area made it impossible to draw definite conclusions from the experiments as a whole although certain deductions could be made from individual cases; these will be dealt with in the current report on green manuring. Some of the more interesting conclusions were drawn from the use of *seet* made from *Sannai* (*Crotalaria juncea*) the utilization of which had been suggested owing to the difficulty in obtaining indigo *seet* consequent upon the reduction of area under this crop. It was found that the *seet water* used in making the *seet* was roughly equal in manurial value to the *seet* itself in the case of the *rabi* crop (oats), but that in the residual effect on the succeeding *kharif* crop (maize) the *seet*, as was expected, proved greatly superior to the *seet water*. In the case of two areas under tobacco, one with normal and the other with comparatively low moisture content in the cold weather, the effect of *seet* as compared with green manure (*sannai*) ploughed in, in the ordinary way, was greater in the dry areas. The differences produced by green manuring in the rate of ripening both of oats and of tobacco were very marked. The effect of superphosphate in conjunction with green manure on the *rabi* crop was marked in soil with good moisture, but inappreciable in plots where the water content was low and the soil itself poor. A large number of observations were made on the changes going on in *seet* during and after fermentation; it was concluded that the value of this material as a manure depends upon numerous factors of which its nitrogen content is the principal; at the same time great differences in the results may be obtained by proper or improper methods of preparation and application, especially the latter, as large quantities of toxic bodies are produced as a result oi the semi-anærobic conditions obtaining during the early stages of its manufacture,

which can totally inhibit root growth if allowed to remain in the soil, being especially injurious to plants in the seedling stage. The time of application appears to be more important than the manner of preparation although these should be interdependent. In the meantime it will be necessary to crop the plots for some time without individual treatment and gain some knowledge of the extent of local variations amongst them. This seems specially necessary in the case of green manuring experiments the results of which are not likely to become strikingly obvious as quantitative differences in the succeeding crop of such an order as to carry them indubitably beyond the range of experimental error.

Studies were made of the development of root nodules on various leguminous plants with special reference to the depth below the surface at which they are formed, the effect of variation in the soil upon their vertical position, and the relation between their development and the age of the plant. With regard to this last, in the case of *Crotalaria juncea* (Sann Hemp) it was clear that each nodule had its own life history independent of that of the plant, forming, developing to maturity, and finally shrinking and drying up to an empty shell ; cultures and sections from nodules at various stages showed coincident changes in condition of the bacteria and bacteroidal tissues.

Nodules in all these various stages of development could be found at the same time on the same plant. Indications were obtained that nodule formation did not take place at that soil level at which most vigorous root growth was found, but tended to occur chiefly where the ratio of air to water was higher than was consistent with maximum root development, this latter appearing to coincide with maximum nitrate formation. A characteristic difference in the character of growth was observed between roots in clay and those in sand with intermediate variations in mixtures of the two and similar changes where the plants were grown in alternate layers of these soils. It was remarkable that even in pure sand nodule development was restricted to a comparatively shallow surface layer very slightly deeper than that found in the case of pure clay. Sporadic development of nodules, insignificant in number, occurred at deeper levels. The most universally prevalent characteristic was the fact that at least 90 per cent. of the nodules present at any one time were found on, or very closely adjacent to, the main stem, this being apparently due partly to the fact that such nodules had a longer life than those formed on more distal portions of the root, showing indeed the specific morphological characters associated with their host and also in part to the fact of this position being coincident with the conditions of æration which appear to favour their growth. An alternative hypothesis might suggest the importation of the specific *radicicola* organism by the seed and its consequent occurrence in the soil only in the neighbourhood of the latter ; this however does not appear a probable explanation in view of the indigenous character of the legumes under observation. The general suggestion would be that nodule formation took place more readily in the earliest stages of the growth of the plant owing

to the lower power of resistance to bacterial invasion which the latter possesses at that time. Rootlets of a similar age but formed at a later period of growth appear to be less readily invaded.

Nitrogen Fixation.—AZOTOBACTER.—Mr. Walton completed the initial stages of his work on Azotobacter in Indian soils the results of which were published in a Memoir which has now been in the Press for some three months. The preliminary survey showed the occurrence of Azotobacter in Indian soils of widely divergent type and situation. Fixation of nitrogen and its increase in amount as a consequence of added carbohydrates was demonstrated in soils in the field. Further work was projected on the symbiotic relationships between the Azotobacter and soil algae, some evidence having been obtained of the widespread and highly important nature of this natural source of soil nitrogen, but this has been temporarily abandoned in consequence of the appointment of Mr. Walton to a commission in the Indian Reserve of Officers.

Fermentation Organisms.—The work on Bakhar was made the subject of a Memoir which was submitted for publication in April and is still in the Press. The relationships between the amylo ferments and the saccharomycetes involved in this question are still being studied.

Yeasts of the cerevisiæ type severally characteristic of the fermentation of mahua and molasses were separated from wild types present and supplied for trial to various firms of distillers; no conclusive reports have been received so far, but in the present condition of this industry in India, it seems unlikely that much progress will be made of the kind essential for success in Europe, owing to the lack of expert knowledge in the distilleries. The success of the fermentation appears to depend upon its rapidity and consequent comparative freedom from bacterial or other contamination, and this rapid fermentation itself depends upon the use of a large quantity of active yeast; it is therefore upon the successful production of the "mass culture" of yeast that efficiency depends and as the only methods of effecting this so far as I know, in India are merely wholesale imitations of European practice, it is not to be expected that total disregard of the very large differences in the conditions under which growth of the yeast takes place in such widely different climates, will lead to any high standard of efficiency. On the other hand, it does not appear probable that any great experience of technical knowledge should be required to make successful modifications and adaptations of European methods to Indian conditions, but some, at least, is essential.

Saltpetre.—Experimental work was carried on during the year in order to obtain some knowledge of the biological actors involved in the production of saltpetre in the soils of Bihar. Information was sought for on the following points:—

(1) Why does this industry flourish in particular localities?

(2) Could it be extended either in the places where it is already established or into other districts?

(3) Could the methods of recovering the nitrate from the soil be made more efficient?

The enquiry is still in an early stage, but it seems clear that the leading factors in determining the localities in which this industry can flourish are (1) a high percentage of lime in the soil, (2) suitable climatic conditions for (*a*) nitrification of organic matter, (*b*) accumulation of the nitrate formed.

These conditions are fulfilled in several districts throughout India including the Punjab and the United Provinces, but it is in Bengal and especially in Bihar that they are most favourable. It has been ascertained that nitrification goes on during the monsoon in soils containing much nitrogenous organic matter such as occurs in the neighbourhood of villages, and that concentration of the nitrates formed is prevented by the rainfall which carried them down, and allows production to go on in the soil stratum in which conditions of food supply and æration favour bacterial action, which latter would, however, be interfered with by accumulation of nitrate beyond a certain concentration. Such a concentration is found in some of the saltpetre earth collected for extraction by the *nuniahs* and as it is of an order many times greater than that necessary to inhibit nitrification, it is clear that it has not been produced *in situ* by this process, but has been arrived at by the evaporation of weak solution of nitrates from the soil surface either in the field or on the walls of houses.

The *nuniah* collect *nuni-mati* or saltpetre earth from haphazard sites selected with reference to the accumulation of nitrogen, characteristic of village sites and cattle sheds, hence he is dependent on uncontrolled supplies of raw material and any expansion of the industry could be effected only either by introducing the *nuniah* into hitherto unexploited districts or by artificial nitrification of nitrogenous organic matter which would otherwise serve some other purpose. An attempt is now being made to discover the extent to which the carrying out of this latter alternative is feasible. Local enquiry has elicited the fact that the *nuniah* does not generally make his business pay until the second or third year, which he attributes to the fact that the amount of nitrate obtained directly by extraction from the earth collected in the neighbourhood is insufficient on the average to pay expenses, and it is only when the accumulation of residual earth (which after extraction is carefully stored) is sufficient in quantity and suitably matured for a second extraction, that paying quantities of saltpetre are obtained.

If this information proves to be reliable it is obvious that a great deal can be done for the industry simply by ensuring that the time spent in maturing the store of residual earth shall be employed to the best advantage, *i.e.*, that the optimum percentage of organic matter and moisture shall be present, that no leaching by rain takes place, and that nitrification shall not be interfered with by the addition of excessive quantities of salts in solution in the "mother liquor" remaining after concentration, which it is the *nuniah's* practice to return to the heap of residual earth. This practice may be harmless

or even valuable up to a point, after which it must tend to lower the rate of nitrification.

The addition of wood ashes is another practice which probably might be modified with advantage after examination. The addition of organic matter will no doubt prove the most likely source of possible improvement; experiments on this point on a considerable scale are in progress.

Potato Rot.—The enquiry into this subject referred to in my report of 1913-14 was completed and a Memoir on the subject has now been in the press for some months. It was shown that the rotting of potato tubers in store was in many cases due to the action of bacteria common in Indian soils; the conditions under which such bacteria were able to attack the tubers were described and preventive measures recommended. The practice of storing tubers in sand as a protection against potato moth appears to be responsible for many cases of rot in consequence of the increased chances of moisture condensation due to the use of earth instead of sand or of imperfect ventilation.

WORK IN THE PROVINCES.

Madras.

Messrs. Harrison and Subramania Aiyar continued their investigation on the gases of swamp rice soils, mentioned in the report of the previous year, with more special reference to the bacterial aspects of the case; they isolated bacteria responsible for the production of various gases found in the mixture obtained from rice soils under swamp conditions.

A bacillus identified as B. Coli was found associated with numerous cases of bud rot in coconut palms in Madras; it is not suggested, however, as having any causative connection with the disease.

Punjab.

A considerable amount of work on the bacteriology of "Reh" soils was carried out at Lyallpur in the laboratory of the Agricultural Chemist to the Government of Punjab by Mr. Barkat Ali, Assistant Chemist. This was on the same lines as those employed by Mr. Barkat Ali whilst under training at Pusa and was directed towards ascertaining the alterations in the condition and activities of the soil complex induced by the field treatment of Reh Soils by draining. It was shown that irrigation and drainage on a field scale produced similar increases in biological activity as were found to result from washing samples of these soils in the laboratory so as to lower their salt content.

Publications.

HARRISON, W. H. & SUBRAMANIA AIYAR, P. A. — Gases of Swamp Rice Soils, Part II. Their utilization for the æration of the roots of the crop. (*Mem. Dept. Agric. India Chem. Series IV No. 1.*)

BARNES, J. H. . . Report of the Agricultural Chemist to the Government of Punjab for 1914-15.

JOSHI, N. V. . . A New Nitrate-forming Organism. (*Mem. Dept. Agric. India. Bact. Series, i, No. 3.*)

WALTON, J. H. . . Azotobacter and Nitrogen Fixation. (*Mem. Dept. Agric. India. Bact. Series, i, No. 4.*)

HUTCHINSON, C. M. & JOSHI, N. V. Bacterial Rot of Stored Potato Tubers. (*Mem. Dept. Agric. India. Bact. Series, i, No. 5.*)

HUTCHINSON, C. M. & RAMAYYAR, C. S. Bakhar :—The Indian Rice Beer Ferment. (*Mem. Dept. Agric. India. Bact. Series, i, No. 6.*)

HUTCHINSON, C. M. . "Turf" (*Agricultural Journal of India, ix, Pt. iv, Oct. 1914*).

" " . Annual Report of the Imperial Agricultural Bacteriologist for 1913-14.

FORESTRY.

I.—SYLVICULTURE

BY

EDWARD MARSDEN, I.F.S.,
Sylviculturist.

Statistical work in typical forest crops.—Progress continued in the accumulation of measurements made in typical forest crops with the object of ascertaining the volume at different ages and under varying conditions of the important species of timber-trees. Only after very many such plots have been measured up will it be possible to frame an estimate of the rate at which the increment is laid on. Until greater knowledge of the growth increment has been obtained, the application of financial forecasts cannot be placed upon a sound basis. Sixteen permanent plots and eighteen temporary plots were thus laid out and measured during the year including those laid out in Bengal, the species dealt with being chiefly *Shorea robusta* and *Cedrus Deodara*.

There are now 187 permanent sample plots, of which 127 are in the United Provinces, 47 in the Punjab, 11 in Bengal, and 2 in the Forest Research Institute experimental garden at Dehra Dun. This work was commenced in 1910-11, and remeasurements after successive periods of five years being prescribed these will be begun in the coming cold weather (1915-16), after which the value of the work done will begin to find expression.

The Sál tree (*Shorea robusta*).—The sylviculture of the Sál tree is one of the chief subjects of special research, and gradually more extensive knowledge is being acquired in connection with the natural regeneration of Sál forests. The advantages of side shelter in comparison with direct shade overhead are becoming established, and opinion seems to be tending towards strip-fellings as a suitable method for obtaining the reproduction of the forests naturally. Further investigation is necessary to ascertain the best direction in which such fellings should proceed, as well as the most favourable width for them. In the course of his tour in Bengal Mr. Troup devoted special attention to the possibilities of artificial reproduction for Sál in combination with the cultivation of field crops; the results of his work are published in his " Note on the Forests of the Duars."

Cedrus Deodara.—A system of clear-felling over small areas has been under trial in Chamba for three or four years; the *débris* from the fellings in these areas is collected in stacks and burnt, after which the soil is hoed up;

the gaps made are about 60 ft. in diameter. This method of natural reproduction is bound to succeed in time, but it appears to be a slow process. The delay is attributable not to the condition of the soil, but rather to lack of seed. The forests in which the gaps have been made are the oldest in the State, but mature trees form only a small proportion of the crop, and they have not been trained to become seed-bearers. The question of shelter is another important factor not completely solved by this method. It seems possible that the enhanced radiation from the sun at high elevations exercises a very desiccating influence on the soil especially when this is combined with the low proportion of water-vapour in the air at these altitudes. If this is the case, the importance of overhead shelter would be greater at a high than at a low altitude. The expenditure upon planting Deodar seems to be seldom justified, unless the conditions of aspect, labour, and soil are all favourable.

Experiments in the Sylvicultural garden at Dehra Dun.—Very numerous observations have been made during the last five years upon the germination, early growth, and rate of growth as exhibited by different species in the Dehra Dun garden. These are now being compiled with a view to publication. Experiments are being continued, and the conditions favourable to the early establishment of seedlings are under investigation. For a few important species the development in the form of a pure crop forms the subject of a special experiment. The effect of overhead shade as contrasted with side shelter has yielded interesting results in the case of Sál, and the experiments with "nurses" for this species have produced a young Sál 52 inches high within 25 months. It remains now to apply the results of some of this work to larger areas under forest conditions.

Developments in Sylvicultural Systems.—It is probable that the work of the Sylviculturist for the next few years will be concentrated upon three main heads: (*i*) the collection of statistics in connection with the rate of growth of crops, (*ii*) suggesting and framing experiments in new methods of reproduction, natural and artificial, since the means adopted for regenerating a crop must always form the basis for the sylvicultural system adopted, and (*iii*) the collection of data about the formation and cost of existing plantations.

During the year seven permanent experimental plots have been laid out with the object of observing the effect upon natural reproduction of shelter in combination with hoeing, burning, etc.

Without artificial assistance it seems possible that certain species as found now in the irregular and untended forests are unable to produce seed in sufficient bulk to stock areas under regeneration. It seems likely that until fairly even-aged mature crops have been established and trained so as to develop large seed-bearing crowns, recourse must also be had to artificial sowing.

The **Working-plans** published during the year present no striking developments. After some 30 years' experience clear-felling for *Casuarina* is recog-

nised as the best system. For the rest, Selection, Coppice with Standards, and Improvement Fellings continue to form the line of least resistance when the sylvicultural character of the species is only partially known. As the sylviculture of the more important species is gradually becoming recognised as the only sound foundation for framing a system of management, a tendency is noticeable to base working-plans now under compilation less upon the condition of the growing stock as exhibited by the proportionate representation of the age classes, than upon the means found by experiment to be most promising for assuring reproduction.

List of Indian Publications during 1914-15.

AITCHISON, P. E. . Working-Plan for the Yekambi-Sonda High Forest Block XXVIII, Bombay Presidency.

ALI BEG, M. M. . . Notes on Grazing in the Forests of the Central Provinces. (*Ind. For. xli, 177.*)

BEST, J. W. . . Working-Plan for the Bilaspur Forest Division, Central Provinces.

BLANFORD, H. R. . Some Notes on the Regeneration of "In" and "Kanyin" in an Upper Burma Division. (*Ind. For. xli, 78.*)

BRADLEY, J. W. . Flowering of Kyathaung bamboo (*Bambusa polymorpha*) in the Prome Division, Burma. (*Ind. For. xl, 526.*)

CANNING, F. . . Twisted Fibres in Chir Pine. (*Ind. For. xli, 112.*)

COPLESTON, W. E. . Cultivation of Natural Teak Seedlings in the Haliyal Teak Pole Forests worked on the Coppice with Standards system. (*Ind. For. xl, 461.*)

DONALD, J. . . Working-Plan for the Elchil Forest of the South Chanda Division, Central Provinces.

DOUGLAS-HAMILTON, J. A. G. Working-Plan for the Anjan and Scrub Jungles of the Dhulia and Pimpalner Ranges of the West Khandesh Division, Bombay Presidency.

DUNBAR-BRANDER, A. A. Working-Plan for the Nagpur Wardha Division, Southern Circle, Central Provinces.

GONSALVES, A. F. . Working-Plan for the Satmala Teak and mixed forests and the above-ghat mixed and scrub forests of Challisgaon, East Khandesh Division, Bombay Presidency.

GOVINDA RAO, P. S. and OTHERS. Marking Standards in the Coppice with Standards system. (*Ind. For. xl, 573 and xli, 131, 153.*)

IMAM-UD-DIN . . Germination of *Quercus incana*. (*Ind. For. xli, 132.*)

KENNY, S. L. . . Rough Scheme of Working for the Khannat Sál Forests of Karanjia Range, South Mandla Division, Central Provinces.

MAJORIBANKS, G. E. . Working-Plan for the North Dangs Range Forests, Surat Agency, Bombay Presidency.

MASCARENHAS, L. P. . Germination of Teak. (*Ind. For. xli, 147.*)

OSMASTON, A. E. . Fire-protection in Chir Forest. (*Ind. For. xl, 387.*)

PARKER, R. N. . . One Year's Meteorological Observations at Changa Manga. (*Ind. For. xli, 6.*)

REBEIRO, V. d'P. . Working-Plan for the *Causarina* Plantations at Nagaon, Revdanda and Akshi in the Alibag Range of the Kolaba Division, Bombay Presidency.

SMYTHIES, E. A. . Notes on the Twisted Fibre in Chir Pine. (*Ind. For. xli, 69.*)

WALKER, N. C. . . The Uniform System in Burma. (*Ind. For. xli, 105.*)

WRIGHT, H. L. . . Eucalyptus Experiments in the Simla Hills. (*Ind. For. xl, 360.*)

ECONOMIC FOREST PRODUCTS

BY

C. E. C. COX, I.F.S.,
Forest Economist.

Economic uses of Deodar Timber.—The enquiry on this subject is being conducted under the following heads :—

(1) *Rate of seasoning and mechanical tests for strength.*—A large number of logs felled at various seasons of the year and from different localities were laid down to season in the open, moisture tests being recorded at regular intervals as well as all physical defects noticed in the timber. The moisture percentage having now fallen below 15 per cent. the logs have been converted and are being subjected to mechanical tests for transverse strain, compression and shearing.

(2) *Minor products.*—Experiments on the utilization of waste wood by the processes of dry and steam distillation and the extraction of Deodar tar and oil have been carried out by the Chemical Adviser during the year. The opinion on the therapeutic value of the steam distilled oil furnished by the Kasauli Institute is not encouraging and the report from the Imperial Institute shows that it is not possible to use it as a substitute for Cedar Oil. The oil is now being tried for imparting perfume to finished leather and the antiseptic properties of the tar as a possible timber preservative is being tested.

Grasses for Paper Pulp.—Arrangements have been made with a Calcutta Paper Mill to carry out tests on a commercial scale on samples of the more important pulp grasses. A tour is being arranged in the Assam grass areas which will be visited in November for the purposes of obtaining figures of outturn and cost of the various species, samples of which will then be made and consigned to Calcutta for testing.

Match Industry.—The solution of the difficulty of finding an entirely suitable timber for match splints seems to be bound up with that of finding a means of extracting spruce (*Picea Morinda*) and silver Fir (*Abies Pindrow*) timber from the hills of Jaunsar. An experiment on practical lines is now being carried out in the Chakrata Division by a firm of matchmakers to determine the possibility of extracting the timber to convenient centres at which it is proposed to erect portable splintmaking machinery. So far the enquiry has not reached a definite conclusion but it is clear that the difficulties of

such extraction as represented by the local forest officers have in no way been exaggerated.

Antiseptic treatment of Timber.—The detailed enquiry into the value of various antiseptics and the power of the various timbers to absorb them has been extended during the year under the following heads :—

(1) The experimental sample plot at Dehra in which small stakes of the timber of 12 different species are treated with various antiseptics and embedded in white ant infested soil side by side with untreated pieces of the same timbers for purposes of comparison has been maintained and extended by the addition of three new antiseptic preparations, *viz.*, " Sideroleum," "Lignolite " and " Brunolinum."

(2) The experiment of treating sleepers of different species of timber with various antiseptics by the open tank method of impregnation was again extended, 460 seasoned sleepers of " Ain "(*Terminalia tomentosa*) were treated in the Betul District, Central Provinces, with a mixture of 33 per cent. of " Solignum " and 67 per cent. Liquid Fuel Oil. This was absorbed to the extent of nearly 10 lbs. per B. G. sleepers in 24 hours. The sleepers were subsequently handed over to the Railway authorities and laid down in the Great Indian Peninsula Railway line.

(3) *Inspections of sleepers laid down in various localities in previous years.*—During the year sleepers of the following species, *viz.*, *Terminalia tomentosa* (Ain), *Pinus longifolia* (Chir), *Pinus excelsa* (kail), *Dipterocarpus tuberculatus* (In), *Dipterocarpus alatus* (Kanyin), treated under the Powell process and laid down in the Eastern Bengal State Railway, North Western Railway at Rohri and Quetta and in the Oudh Rohilkhand Railway near Lhaksar were inspected. The sleepers have been now four years in the line and results of this year's inspection show that all sleepers are free from white-ant attack ; the Dipterocarps and Pines show signs of rail cut indicating the necessity for bearing plates. Ain is wearing well and only shows signs of cracking where knots exist. Both Kail and Chir show signs of cracking, the latter to a greater extent than the former.

(4) *Experiments in connection with the proposed erection of creosting pressure plants in India.*—The collecion of data with a view to the possible introduction of creosoting pressure plants either in Assam or the Andamans, was rendered necessary owing to the fact that practically nothing was known regarding the property possessed by the various sleeper timbers to respond to such treatment and accordingly a series of experiments is being carried out. The object of the first of these was to ascertain whether the Andaman Gurjan (*Dipterocarpus turbinatus*) would

respond to the open tank treatment. For this purpose 50 Gurjan sleepers were treated in open tanks at Hardwar with the results that it was found that a B. G. sleeper would absorb on an average of 15 lbs. cresote in 24 hours. The next experiment consisted in testing the more important Assam sleeper timbers by both the open tank and pressure systems. The Assam Oil Company at Digboi very kindly made arrangements for the pressure treatment and the result of experiments carried out by Mr. Pearson in February lead to the following conclusions :—

(i) Artificial drying of sleepers previous to treatment is advisable in the moist climate of Assam.

(ii) *Dipterocarpus pilosus* (Hollong) *Cynometra polyandra* (Ping) and *Magnolia* (Gohari Sapa) can be treated either by the open tank or pressure process and take up oil readily.

(iii) *Terminalia myriocarpa* (Hollock) cannot be treated under open tank method but is susceptible to treatment under pressure.

(iv) *Altingia excelsa* (Jutuli), *Eugenia* (Jamuk) and *Artocarpus Chaplasha* cannot be treated by the open tank method and further tests with these species under the pressure process still remain to be carried out.

In addition to the above experiments 100 Gurjan sleepers from the Andamans have been sent to England for treatment by the full cell pressure process. The tests were carried out under varying conditions and results show that when subjected to a pressure of 150 lbs. for 3 hours B. G. sleepers take up an average of 20·6 lbs. and M. G. 11·2 lbs. of creosote per sleeper, the oil penetrating to the centre in every case.

The results of tests under the " Rueping " process are still awaited. Eight B G. sleepers of each of the 10 most important sleeper timbers have been despatched to a home firm for treatment by this process. The relative merits of the full cell or ordinary pressure and the Rueping process are being now examined by Mr. Pearson on the spot so that reliable data on the several points at issue should soon be available.

Tanning Products.—The necessity for exhaustive enquiry into the future of the Indian Tanning Industry has now been realized and the appointment of a tanning expert to investigate the development of the manufacture of tanning extracts from the numerous tanning products of India and Burma has been recently sanctioned. At the suggestion of Professor Dunstan of the Imperial Institute a paper on the " Mangrove forests of British India " was written by Mr. Pearson for the congress of Tropical Agriculture in London and the importance of the subject was brought to the notice of the leading tanning firms of the United Kingdom by Professor Dunstan. Replies received from the firms were however disappointing, the general opinion being that Man-

grove bark is not much appreciated by tanners in England for the reason that some qualities are highly coloured and others do not make good leather. It would also appear that the Borneo Company's Mangrove tanning extract is not used in the United Kingdom to any appreciable extent.

Physical and Mechanical Properties of certain Timbers.—

(1) *Seasoning of timber.*

(*a*) *Natural seasoning.*—A detailed enquiry has been undertaken with the object of determining the best methods of seasoning the more important timbers with special reference to the relative advantages of girdling, seasoning in the open and under shelter, seasoning first in fresh or salt water and then under shade, the effect of felling at different seasons of the year, of converting timber in the green as compared to the dry state as well as the effect of applying " Ligno " or " Loracine " paints, tar and cowdung to the ends of logs when seasoning. The experiments are being carried out for over 30 species.

(*b*) *Artificial seasoning.*—The essential need for air dry timber for sleepers intended for creosote impregnation by the pressure process in such damp climates as Assam or the Andamans having been realized the various plants for artificial seasoning of timber are now being inspected and reported upon by Mr. Pearson in England with the assistance of the Forest Engineer. Data regarding the Sturtevant, Erith and other plants have now been collected and will be available for submission when the question of the erection of a creosoting pressure plant is considered.

(2) *Mechanical tests on timbers.*—A considerable number of tests on various timbers have been carried out during the year, among which the following may be noted :—

(*a*) *Relative strength of Chir* (*Pinus longifolia*) *timber grown in various localities in the Punjab.*—These tests were carried out to ascertain the truth of a local belief that timber from trees grown at higher elevations or in favourable localities as regards aspect and soil is stronger than that from trees grown at low elevations or in poor soil. Tests for *transverse* strength, compression and shearing were carried out both at Sibpur Engineering College and at Dehra the results of which justify the following conclusions :—

(*i*) Sapwood is as strong as heartwood.

(*ii*) In transverse strain and shearing timber from young trees is stronger than that from old grown under similar conditions, but in the case of compression the reverse is the case.

(*iii*) Timber from trees grown at good elevations and under favourable conditions of aspect and soil is stronger than that from (*a*) trees grown at low elevations or (*b*) trees grown even in favourable elevation and aspect but in poor soil.

(*iv*) Timber from trees grown in favourable elevations and aspect but in poor soil is stronger than that from trees grown at low elevations.

(*b*) *Strength of Chir timber with various degrees of twisted fibre as compared to straight fibred timber.*—This test was carried out in order to ascertain whether sleepers with twisted fibre are mechanically weaker than those with straight fibres. Nine sleepers with various degrees of twist were tested for transverse strength, the stress being applied both tangentially and radially. Results show that the average transverse strength of timber with twist up to 15° is 3·5 as compared to 4·25 tons per square inch in straight fibred timber. The strength of sleepers with twist greater than 15° is extremely low.

Finding new markets and uses for Timber.—Bulletins dealing with the uses, outturn and market value of three species, *viz.*, *Lagerstrœmia parviflora*, *Dalbergia latifolia* (Rosewood) and *Heritiera minor* (Sundri) have been compiled and are now in the Press. Information regarding three other species has also been collected.

The attempt to place " Sundri " timber from Bassein on the Calcutta market is progressing and one of the leading timber firms has shown considerable interest in the business which however cannot be expected to develop fully until after the conclusion of the European War.

Gums, Resins and Oleo-Resins.—The *Boswellia serrata* (Salai) gum-resin enquiry is now approaching a definite conclusion. During the year samples of the oil and rosin, products of steam distillation, were forwarded for valuation to the Imperial Institute, London. The report on these has been received and is to the effect that the oil closely resembles American Turpentine Oil except as regards smell and is of excellent quality and will readily command a market, the rosin on the other hand is of poor quality, the defects being low saponification value and bad odour. Another experiment is now being carried out under the solvent process. The quality of the gum and resin produced by this process appears to be far superior to that produced by steam distillation and samples are therefore being forwarded to the Imperial Institute for a further report.

As regards the prospects of an industry arising from the tapping of *Boswellia* it cannot be said that these are at present very hopeful, the chief obstacles being the relatively small amount of resin exuded and consequently the high cost of the crude product. Reports from the local forest officers also indicate that tapping may permanently damage the trees so that investigation on this

point, *viz.*, whether the trees are damaged by tapping, as well as the best of methods of tapping to obtain the maximum yield is to be undertaken during the coming working season.

Hardwickia pinnata.—Oil and rosin from this oleo-resin were prepared by the Chemical Adviser and forwarded to a number of firms in India, America and England for valuation. Replies are still awaited but those received from the Imperial Institute and also from a Calcutta firm of varnish makers are not encouraging and no use has yet been found for either the oil or the rosin.

Fibres.—The attempt to discover the best method of retting *Helicteres Isora* fibre and to find a market for it has been continued with satisfactory results. The defects in this fibre are its colour and leafy nature which causes lumps in the material. The result of sending a consignment to England for valuation showed that the cost of landing the fibre in England amounted to Rs. 200 per ton whereas the price offered for it was Rs. 105 only. Accordingly enquiries are now confined to finding a market for this fibre in India. The results of experimental retting of a sample from the Lansdowne Division, United Provinces, at Dehra indicate that the fibre from young stems of one season's growth is best and that the stems should be cut at the end of the rains when they are full of sap.

The most successful experiments on this fibre have been carried out in the Nagpur Wardha Division of the Central Provinces where the Divisional Officer Rao Bahadur Shrinivasulu Naidu succeeded in obtaining an almost white fibre, a 5-maund sample of which was forwarded to a leading Calcutta rope factory for valuation. The firm reported most favourably on this consignment. The only faults in the fibre are the root ends which are apparent in the yarn and spoil the rope, indicating the advisability of cutting the stems some distance from the ground.

Oil from Grasses, Flowers and Seeds.—*Rosha Oil enquiry.*—This enquiry was brought to a close and a detailed note written on the subject by Mr. Pearson is now in the Press. The portable steam distillation plant was taken to Chikalda, Berar, by Mr. Pearson, in November and set up side by side with the locally used direct fire still. A series of distillations with both dry and green grass of both the varieties " Sofia " and " Motia " of Rosha grass (*Cymbopogon Martini*) were carried out and the superiority of steam distillation was demonstrated to the local distillers, the detailed results being tabulated in a note which will shortly be ready for publication.

Paving Blocks.—A consignment of 98 tons of Sál timber consisting the waste ends from sleeper conversion was forwarded to Calcutta from the Balaghat Division, Central Provinces. The timber was there converted by a Calcutta firm into 41 tons of blocks, wastage amounting to 57 tons. Altogether 39,000 blocks were delivered to the Calcutta Corporation who were compelled to reject 20,400 on account of faulty cutting. The remaining blocks were laid in the road before the break of the monsoon and a report on their condition recently received from the Corporation shows that

the blocks are swelling badly in the road and are thus likely to prove unsatisfactory. A similar experiment was undertaken in the North Kanara Division, Bombay, from which 9,260 creosoted and 10,290 untreated "Jamba" (*Xylia dolabriformis*) and 19,700 teak blocks have been supplied to the Bombay Municipality but have not yet been laid in the road. The experience gained up to date in this experiment indicates the necessity for special block cutting machinery and enquiries regarding the necessary plant are now being instituted. Under existing conditions the cost of outturn landed in Calcutta or Bombay is prohibitive and inspection of the blocks in the road during the coming season will show whether these timbers are likely to produce a suitable paving material.

Pencil Industry.—The want of a suitable timber for pencils besides that of *Juniperus macropoda* from Baluchistan which is becoming increasingly difficult to obtain, is being acutely felt by the Calcutta pencil makers and every effort has been made to render help in this direction during the year. Five species were sent to the firm for test from Coimbatore but the results were disappointing, it being found that the heartwood of only one species, *viz.*, *Protium caudatum* was suitable, and for second grade pencils only. Logs of *Larix Griffithii* from Sikkim and *Abies Webbiana* from Darjeeling were also despatched to and tested by the firm but were found unsatisfactory. A log of *Manglietia insignis* from Assam was also supplied but the results of tests on this timber are not yet known.

Cask Timbers.—Sample logs of *Grewia tiliæfolia* were sent on request to a large Glasgow firm and also to an Indian brewery for purposes of test. Up to date reports on the results of tests have not been received.

At the Bhowali turpentine distillery it was found that excellent barrels could be made of Chir timber for packing rosin, also smaller sized barrels of better quality were being tried for bringing in the crude oleo-resin from the tapping areas.

Timber suitable for Bobbin manufacture.—On account of the War the supply of bobbins for jute and other mills from Europe having failed a demand for a suitable indigenous timber for this purpose arose during the year. At present the want appears to be supplied from Japan whence a cheap grade of bobbin is being imported. As soon as the demand arose the enquiry was taken up and more than thirty Indian timbers have been supplied to a Calcutta firm from various localities in India. These are now being seasoned and will be tested for suitability next season.

Solid Bamboos for Lance Shafts.—A brisk demand for lance shafts has arisen during the year and full enquiries are being made and names of contractors furnished to exporting firms. Enquiries indicate that the most likely centres are Bareilly, United Provinces and Hoshangabad and Chanda in the Central Provinces. All efforts are being made to induce the bamboo contractors in these districts to take up this business. Exploitation has com-

menced and it is hoped that an adequate supply of these bamboos will be available during the coming season.

Economic and Wood Museums.—During the year the timber and economic collections were transferred to the new Research buildings at Chandbagh. The cabinets for the economic collections were installed by a Calcutta firm in December and the arrangement of the collections has now been completed. The work of recataloguing the collections is in progress. A number of specimens in the form of large slabs has been added to the timber museum from Assam, the Punjab and the Central Provinces and a large number of specimens for experimental purposes was also received from the various provinces.

List of publications on forest economic matters published during 1914-15.

ALLEMAN, G. . . Quantity and Character of Creosote in well preserved timbers (*Journ. Soc. Chem. Industry, xxxiii, 832*).

BILBROUGH, S. B. . Process for extracting Tannin from bark, wood or other vegetable materials (*Journ. Soc. Chem. Industry, xxxiii, 840*).

BOSANQUET, N. C. S. . The tapping interval of Rubber (*Trop. Agri. xliii, 409-411*).

CAMPBELL, W. B. . Preservative Treatment of Wood (*Journ. Soc. Chem. Industry, xxxiv, 257-58*).

CARTER, H. A. . . Note on Ramie fibre (*Ind. Planters Gaz., lxii, 428-29*).

CASTONA, J. H. . . Process of extracting Turpentine and Rosin from wood (*Journ. Soc. Chem. Industry, xxxiii, 3020*).

CAYLA, V. . . . The Proper Method of preparing Hevea Rubber (*Trop. Agri. xliv, 73-78*).

MITCHELL, W. G. . Treated Wood Block Paving (*Dept. of Interior, Canada Forestry Branch. Bull. No. 49, 1915*).

PEARSON, R. S. . . Note on the absorption of Water by certain timbers (*Ind. For., xl, 513-14*).

" " . . Note on the Method of laying sleepers in England and in India (*Ind. For., xl, 570-73*).

" " . . Experiment carried out at Tanakpur in connection with the Antiseptic Treatment of sleepers (*Ind. For., xli, 148-50*).

" " . . Preliminary Note on the preparation and treatment of *Xylia dolabriformis* Paving Blocks at the Kesralga Saw Mill, North Division, Kanara, Bombay Presidency (*Ind. For., xli, 150-53*).

PRITCHARD, T. W. . Process of producing pure Turpentine (*Journ. Soc. Chem. Industry, xxxiii, 1020*).

SINGH, PURAN . . A further note on the best season for collecting Myrabolans as tanning material (*Ind. For. xli, 17-21*).

" . . A further note on the oil value of some sandal woods from Madras (*Ind. For. xli, 123-31*).

SMYTHIES, E. A. . . The Resin Industry in Kumaon (*For. Bull. No. 26, 1914*).

SURFACE, H. E. . . Effects of varying certain cooking conditions in producing soda pulp from Aspen (*U. S. Dept. of Agr. For. Service Bull. No. 80, 1914*).

" " . . Suitablity of long leaf pine for Paper Pulp (*Journ. Soc. Chem. Industry, xxxiii, 857*).

TEESDALE, C. H. . Relative resistance of various conifers to injection with Creosote (*U. S. Dept. of Agri. Forest Service Bull. No. 101, 1914*).

" " . . The Bleeding and Swelling of Paving Blocks (*January 1915*).

THELEN, R. . . The Utilization of Saw Mill Waste (*Timber Trades Journ. lxxvii, Pages 13 & 14*).

WEISS, H. F. . . Tests of Wood Preservatives (*U. S. Dept. of Agri. Forest Service Bull. No. 145, 1915*).

ZOOLOGY.

1.—GENERAL ZOOLOGY AND PHYSICAL ANTHROPOLOGY.

BY

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As in previous years, this report deals mainly with the zoological work undertaken in the Zoological and Anthropological Section of the Indian Museum. Other work having a bearing on the Fauna of India is dealt with very briefly, and only so far as published results are concerned, in a note prefixed to Dr. Chaudhuri's list of publications below.

Zoological and Anthropological Work of the Museum.

COLLECTIONS.

A.—Anthropological.

The most important additions to our anthropological collection have been (1) a large series of fishery apparatus from the Chilka Lake collected in the Puri and Ganjam districts by Dr. Annandale and Dr. B. L. Chaudhuri and (2) a series of full-figure photographs of Calcutta Eurasians taken in our new anthropometrical laboratory in definite positions and on a definite scale. We have also received presents of obsolete firearms from several Bengali gentlemen. These weapons are of scientific interest as illustrating the evolution of modern guns and revolvers.

B.—Zoological.

His Excellency Lord Carmichael has continued to employ collectors in the Darjeeling district and to send the material they obtain to the Indian museum for selection and distribution.

We have received important miscellaneous specimens from Captain Hutchinson of the 3rd Brahmans (from Singapore), Mr. T. Clapton (from the Madras Presidency), the officers of the R. I. M. S. " Palinurus " (from the Persian Gulf) and Mr. J. Taylor (from Angul, Orissa). The Revd. W. S. Sutherland has also sent us an interesting collection of spiders and tadpoles from Kalimpong in the Darjeeling district, while Mr. B. H. Buxton brought us in person an important series of Pedipalpi, Orthoptera and Crustacea from the

Malay Peninsula and Ceylon. Major Clayton Lane, I.M.S., has deposited in the Museum co-types of the new species of Nematodes he has described.

The large collection of Passalid beetles accumulated by the late Dr. van de Poll was purchased from a London dealer.

The most important accessions, however, were those made by members of the staff, more particularly in connection with the survey of the Chilka Lake undertaken by Dr. Annandale and myself.

Mr. Graveley obtained a large collection of insects, arachnids, reptiles and batrachia in the State of Cochin, which he visited in September and October.

A small general collection obtained by Dr. Annandale at Ennur near Madras is proving of considerable value for comparison with that made in the Chilka Lake.

A collection of marine and fluviatile animals, chiefly Decapod Crustacea, was made by myself during a short visit to Port Blair in the Andaman Islands in February and March.

The following collections have been interned in Germany and Austria, where they were in the hands of specialists at the outbreak of the war :—

IN GERMANY—The whole collection (with a few exceptions) of Gephyrean worms with Dr. J. W. Spengel at Giessen; the whole collection (with a few exceptions) of Syngnathidæ (fish) with Dr. G. Duncker at Hamburg; the greater part of the collection of Actinians with Dr. F. Pax at Breslau; the whole collection of Apioninæ (Coleoptera) with Dr. W. Wagner at Strassburg; a collection of Gyrinidæ and Dytiscidæ (Coleoptera) with Dr. R. Ahlwarth at Berlin; a small collection of Cicindelinæ (Coleoptera) with Dr. W. Horn at Berlin; The Abor collection of Erotylidæ and Endomychidæ (Coleoptera) with Herr S. Schenkling at Berlin; a small collection of Chrysomelidæ (Coleoptera) with Dr. H. Kuntzen at Berlin: the whole collection (with a few exceptions) of Dolichopodidæ (Diptera) with Dr. B. Lichwardt at Berlin; the Abor collection of Carabidæ (Coleoptera) with Dr. H. Kolbe at Berlin; the whole collection of Cistelidæ and Lagridæ (Coleoptera) with Dr. F. Borchmann at Hamburg; a collection of Diptera Pupipera with Dr. P. Speiser at Basel; a large collection of freshwater Gastropods (Mollusca) with Dr. W. Kobelt at Frankfurt. The last two collections have been abroad for a long time and we had been attempting in vain to recover them for some years before the war.

IN AUSTRIA-HUNGARY.—The whole collection of Discognathus (fish), including several types, with Dr. K. Pitschmann at Vienna; a small collection of Anthicidæ (Coleoptera) with Dr. Hans E. von Krekich-Strassaldo at Trieste; a fairly large collection of Staphylinidæ (Coleoptera) with Professor Max Bernhauer of Grunberg; practically the whole collection of Pelogonidæ and Tingidæ (Rhynchota) with Dr. G. Horvath at Buda-Pesth.

The following collections were in Belgium at the beginning of the war :— A collection of Coprinæ (Coleoptera) with Dr. J. Gillet at Brussels; the Abor collections of Hydrophilidæ (Coleoptera) with Dr. A. d'Orchymont at Ypres.

Several correspondents in Germany took pains on the outbreak of war to despatch reports on collections that were with them at the time and attempted to return the specimens. The reports were received, but unfortunately it was not possible to get the collections through the post.

Mr. F. H. Gravely, Assistant Superintendent, submits the following report on the entomological collections :—

Araneæ.—The spiders of the Abor Expedition are still with Dr. Nathan Banks. I have prepared a catalogue of our Mygalomorphæ which is now in the press. The *Araneæ Veræ* are being gradually sorted out into groups.

Phalangidæ.—Dr. C. Roewer returned all our specimens that remained with him shortly before the outbreak of war.

Acari.—Professor G. Nuttall and Mr. C. Warburton are still working on ticks for us. Mites from fowls are being sent to Mr. S. Hirst.

Thysanura.—Still in the hands of Professor F. Silvestri.

Collembola.—Dr. G. H. Carpenter still has the *Collembola* of the Abor Expedition.

Orthoptera.—Dr. M. Burr has named and returned nearly all the earwigs we have sent him, and Mr. J. L. Hancock the Tettigids. Mr. H. S. Leigh and Dr. E. Giglio-Tos still retain the material that is with them. Dr. A. Griffini has named and returned all the Stenopelmatids and Gryllacrids sent to him.

Termitidæ.—The specimens sent to Revd. Father Assmuth were returned when he heard he was likely to be interned as an alien enemy. Specimens from one nest have been sent to Professor N. Holmgren and we hope he will agree to name these and others that are ready to be sent out.

Mallophaga.—Still with Professor V. L. Kellog, whom we have asked to retain the specimens for the present.

Odonata.—All our unnamed dragon-flies and a selection from the named collection have been sent to Mr. F. F. Laidlaw.

Neuroptera (*sensu lato*).—Prof. J. G. Needham has not yet returned the specimens with him.

Trichoptera.—Nothing more has been received from Dr. Betten.

Hymenoptera.—Mr. Morley's work on our Hymenoptera Parasitica has ceased. Dr. Grandi is working on our fig-insects and has already named and returned some of them. Dr. W. M. Wheeler's work on our ants and Dr. S. A. Rohwer's work on our sawflies continues.

Coleoptera.—The work of Mr. G. J. Arrow, Mr. S. Maulik, Mr. C. J. Gahan, and Mr. G. A. K. Marshall on our collection still continues. Dr. A. Griffini has commenced work on our *Bolbocerinæ;* and I have practically completed a catalogue of our *Lucanidæ*, in which I have received valuable assistance from Mr. Arrow. Our *Meloidæ* sent to Dr. Creighton-Wellman have been recovered by the Tulane University of Louisiana, where they are

to remain till the end of the war if no one wishes to work on them in the meantime.

Diptera.—The work of Mr. E. Brunetti and Prof. M. Bezzi still continues.

Thysanoptera.—Still with Mr. R. S. Bagnall.

Aphaniptera.—The Hon'ble Chas. Rothschild has returned all the fleas sent him.

Hemiptera.—The work of Mr. W. L. Distant, Mr. E. A. Andrews, and Dr. P. van der Goot continues. Mr. Distant has described several new species from our collection during the year, and we are sending him a number of further specimens of *Homoptera* in connection with the "Fauna" volume that he has in hand.

Communication with the following specialists has been interrupted by the war :— Father Assmuth, R. Ahlwarth, W. Horn, J. Gillett, H. Bickhardt, S. Schenkling, H. Kuntzen, W. Wagner, F. Borchmann, E. von Krekich-Strassaldo, W. H. Evans, B. Lichwardt, J. J. Keiffer, P. Speiser, Max Bernhauer, A. d'Orchymont, Winn Sampson, G. Horvath, K. G. Blair, C. G. Nurse, and H. Kolbe. No material remains, however, with Father Assmuth, Dr. Bickhardt, Col. Nurse or Capt. Evans.

Public Galleries.

The re-arrangement of the Insect Gallery has continued to make good progress.

In the last year's report reference was made to a scheme for the re-arrangement of the Invertebrate Gallery, then under consideration. It was decided to spend a considerable amount of money in re-arranging a part of this gallery, with entirely new cases and fittings. The wood-work was completed by Chinese carpenters and several large cases erected, when the war rendered it impossible to obtain plate-glass at rates within our means, and the whole gallery has had to wait indefinitely in a disorganised and unfinished condition.

Old specimens of several common Indian mammals have been replaced in the large Mammal Gallery by fresh examples.

In the Ethnological Gallery a series of figures and prints have been set up to show the different popular conceptions of the *Dassavatar* in different parts of India. Some of the fishery apparatus from the Chilka Lake has also been exhibited.

Field-work.

Field work at the Chilka Lake occupied our attention for a considerable part of the year under review and was completed only in January 1915. Dr. Annandale and I visited the lake in April, June, July, September and December, 1914 ; Dr. Gravely in August and Dr. Chaudhuri in December and January. Owing to the necessity of completing this work, we were obliged to postpone our proposed survey of the Siju Cave in the Garo Hills.

In October Mr. Gravely spent several weeks in the forests of Cochin, where he received great personal assistance from His Highness the Rajah (now the ex-Rajah) and the Dewan, Mr. J. W. Bhore.

In January Dr. Annandale visited Madras to take part in the second Indian Science Congress and also spent several days at Ennur, in the neighbourhood, in order to obtain specimens of the brackish-water fauna for comparison with that of the Chilka Lake.

I myself stayed for some weeks at Port Blair in the Andamans in February and March, partly in order to assist the authorities in re-arranging their local museum and partly to collect Crustacea and other aquatic organisms. During my visit I received much valuable assistance from Mr. R. F. Lowis, Deputy Superintendent, Port Blair.

Mr. R. Hodgart, Museum Collector, accompanied us on most of our tours and showed conspicuous energy and resource in the field.

Research.

The attention of Dr. Annandale and myself, so far as zoological research is concerned, has been directed mainly to working out our collections from the Chilka Lake. Considerable progress has been made and we hope to publish a great part of the results in 1915. A special volume of the "Memoirs of the Indian Museum" will be devoted to them.

Dr. Chaudhuri and Mr. Gravely have continued the work in which they were engaged last year, while Mr. Brunetti has again devoted considerable time to the arrangement and description of Diptera in the collection.

Captain R. B. Seymour Sewell, Surgeon Naturalist to the Royal Indian Marine, was engaged in an investigation of the Copepods of the Chilka Lake when the war broke out. Soon after he was transferred to Aden, where facilities for a continuation of his work are lacking. On account of the war no marine investigations were carried out on the R. I. M. S. "Investigator" during the season 1914-15.

Mr. T. Southwell, Deputy Director of Fisheries, Bengal, has worked in the Museum, so far as his other duties permitted, chiefly on questions concerning the well-being of the freshwater and estuarine fisheries.

As regards anthropological research, Dr. Annandale has continued the anthropological investigations referred to in last year's report. A small laboratory has been fitted for the purpose and a large number of measurements of Calcutta Eurasians has been made. Many of them have also been photographed in full figure and a comparative series of portraits of other inhabitants of Calcutta has also been obtained.

Lecture Scheme.

Two courses of lectures were delivered in the Indian Museum during the year under review; out of the eleven lectures given, seven dealt with zoolo-

gical subjects. The Summer Course in 1914 consisted of a series of six lectures on "Insects and Spiders of Calcutta" by Mr. F. H. Gravely, while one of those delivered early in 1915 was entitled "A Naturalist's View of the Chilka Lake" by Dr. N. Annandale.

List of Publications on Indian Zoology.

The following list of books, memoirs, etc., that have a direct bearing on Indian Zoology and were published between the months of August 1914 and August 1915 has been drawn up as usual by Dr. B. L. Chaudhuri.

Of work published by the Indian Museum attention may be drawn to the comprehensive monograph of the Passalid beetles of the Oriental Region by Mr. F. H. Gravely and to the appearance of the first part of the volume devoted to the results of the faunistic survey of the Chilka Lake. Two further parts of the special volume dealing with the zoological results of the Abor Expedition of 1911-12 have been published.

Attention may also be directed to the series of reports, published in the Journal of the Bombay Natural History Society, describing the results of the Society's survey of Indian mammals and to the papers by Mr. E. C. Stuart Baker and Major H. H. Harington on Indian birds, published in the same Journal.

A volume published in the "Fauna of British India" series by Mr. G. K. Gude deals with certain families of land-shells.

PROTOZOA.

ADIE, H. . . . On the Sporogony of *Hæmoproteus columbæ*. (*Ind. Journ. Med. Research, ii, 671.*)

ALCOCK, A. . . . The *Hæmoproteus* of the Indian Pigeon. (*Nature, xciii, 584.*)

CHATTERJEE, G. C. . On a five flagellate *Trichomonas* (n. sp.) parasitic in Man. (*Ind. Med. Gaz., l, 5.*)

" " . On a Macrostoma found in human intestinal contents. (*Ibid., l, 135.*)

MACKIE, F. P. . . Note on the parasite of Bat Malaria. (*Ind. Journ. Med. Research, ii, 375—376.*)

" " . . . A Flagellate infection of Sand-Flies. (*Ibid., ii, 377—379.*)

de MELLO, F. . . . Preliminary note on a new Hæmogregarine found in pigeon's blood. (*Ind. Journ. Med. Research, iii, 93.*)

PATTON, W. S.. . The behaviour of the parasite of Indian Kala-Azar in the Dog-Flea, *Ctenocephalus felis*, Bouche. (*Ind. Journ. Med. Research, ii, 399—403.*)

PORIFERA.

ANNANDALE, N. . . Indian Boring Sponges of the family *Clionidæ*. (*Rec. Ind. Mus., xi, 1.*)

" . . Notes on Freshwater Sponges. (*Ibid., xi, 171.*)

" . . Sponge-Fauna of the Chilka Lake. (*Mem. Ind. Mus. v, 23.*)

CŒLENTERATA.

ANNANDALE, N. . . Fauna of the Chilka Lake. The Cœlenterates of the Lake, with an account of the *Actiniaria* of Brackish water in the Gangetic Delta. (*Mem. Ind. Mus., v, 65.*)

ANNANDALE, N. & KEMP, S. Fauna of the Chilka Lake. Ctenophora. (*Mem. Ind. Mus., v, 115.*)

PARSHAD, B. . . A short note on *Hydra oligactis*, Pallas. (*Rec. Ind. Mus., xi, 349.*)

VERMES.

ANNANDALE, N. & KEMP, S. Fauna of the Chilka Lake. The Echiuroidea of the Lake and of the Gangetic Delta. (*Mem. Ind Mus., v. 55.*)

LANE, C. . . . Bursate Nematodes from the Indian Elephant. (*Ind. Journ. Med. Research, ii, 380.*)

" " . . . Suckered Round-Worms from India and Ceylon (*Ibid., ii, 655.*)

" " . . . *Artyfechinostomum sufrartyfex.* A new parasitic Echinostome of Man. (*Ibid., ii, 977.*)

" " . . . A further note on Bursate Nematodes from the Indian Elephant. (*Ibid., iii, 105.*)

" " . . . *Falcaustra falcata.* (*Ibid., iii, 109.*)

RAILLIET, A., HENRY, A. ET BAUGHE, J. Sur les Helminthes de l'Elephant d'Asie. Note complementaire. (*Bull. Soc. Pathol. Exot. Siège. Soc. Inst. Pasteur, viii, 119.*)

SHIPLEY, A. E. . . Exotic Leeches. (*The Minor Horrors of War, 168.*)

SOUTHWELL, T. . . A short account of our present knowledge of the Cestode Fauna of British India and Ceylon. (*Journ. Asiat. Soc. Bengal, x, 139.*)

" " . . *Amphilina magna*, n. sp. from the coelom of *Diagramma crassipinum*. *Notes from the Bengal Fisheries Laboratory, Indian Museum.* (*Rec. Ind. Mus., xi, 326.*)

SOUTHWELL, T. . . On Helminths from fish and aquatic birds in the Chilka Lake. (*Ibid.*, *xi*, *331.*)

STEPHENSON, J. . . Littoral Oligochæta from the Chilka Lake on the east coast of India. (*Rec. Ind. Mus.*, *x*, *255.*)

,, . . On a collection of Oligochaeta, mainly from Northern India. (*Ibid.*, *x*, *321.*)

,, ,, . . Fauna of the Chilka Lake: Oligochaeta. (*Mem. Ind. Mus.*, *v*, *139.*)

STEWART, F. H. . Report on a collection of free-living Nematodes from the Chilka Lake on the east coast of India. (*Rec. Ind. Mus.*, *x*, *245.*)

WHITEHOUSE, R. H. . Land Planarians from the Abor Expedition. (*Rec. Ind. Mus.*, *viii*, *455.*)

CRUSTACEA.

ANNANDALE, N. . . New and interesting Pedunculate Cirripedes from Indian Seas. (*Rec. Ind. Mus.*, *x*, *273.*)

,, ,, . . Fauna of the Chilka Lake: Cirripedia. (*Mem. Ind. Mus.*, *v*, *135.*)

COLLINGE, W. E. . Description of a new species of Terrestrial Isopod from India. [*Ann. Mag. Nat. Hist.* (*ser. 8*), *xiv*, *206.*]

,, ,, . Terrestrial Isopoda. (*Rec. Ind. Mus.*, *viii*, *465.*)

,, ,, . Contributions to a knowledge of the terrestrial Isopoda of India. (*Ibid.*, *xi*, *143.*)

HENDERSON, J. R. . Hermit-crabs from the Chilka Lake. (*Rec. Ind. Mus.*, *xi*, *25.*)

SOUTHWELL, T. . . Description of a new species of Isopod Crustacean parasitic on the Bhekti (*Lates calcarifer*). *Notes from the Bengal Fisheries Laboratory, Indian Museum.* (*Rec. Ind. Mus.*, *xi*, *311.*)

ARACHNOIDEA.

GRAVELY, F. H. . Notes on Indian Mygalomorph Spiders. (*Rec. Ind. Mus.*, *xi*, *257.*)

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INSECTA.

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ZOOLOGY.

II.—ECONOMIC ZOOLOGY.

Part I.—Agricultural Entomology.

BY

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1.—Work at Pusa.

Crop pests.—Cotton-pests.—Experiments.—Experiments, which are still in progress, were made to test the relative immunity of different varieties of cotton to attacks of Bollworm (*Earias*). A large number of sowings was made of numerous cottons from the United Provinces, the Punjab, the Central Provinces, and Bombay in combination with other malvaceous plants, and weekly counts made of the bollworm infestation. The bollworms found were also examined for the presence of parasites, which were recorded, bred out and liberated in the experimental area. So far as noted hitherto the infestation of *Earias* by *Rhogas* is remarkably small (less than 5 per cent.) even under the most favourable conditions, and it would appear that the influence of *Rhogas* has been greatly exaggerated. In May and June 1915, in compliance with a request from the Director of Agriculture, all the *Rhogas* pupæ obtained were sent to the Punjab to assist in establishing the parasite there.

Some work has also been done on the life history of *Machærota planitiæ* whose nymph lives in a curious calcareous tube on stems of cotton. The presence of this insect frequently stunts the growth of the young shoots and it may occur in sufficient numbers to do considerable damage.

Sugarcane Borers.—Borers in sugarcane (both new sowings and ratoon canes), maize, juar, and rice stems and stubble have been collected and the insects bred out for further study and comparison. Affected canes were also received from the North-West Frontier Province and the insects reared. In March 1915 fresh sowings of cane were made with maize as a trap crop and, as soon as the presence of borers became apparent, these were collected, counted and reared for further study to ascertain whether the borers in cane and maize are really distinct ; this experiment was not concluded at the end of the year.

Garden Pests.—The study of pests of fruit-trees, flowers and vegetables was continued and illustrations made for a Bulletin on Fruit-pests.

Parasite of Scale Insects.—With a view to sending parasites of *Aspidiotus aurantii* to Italy, a study was begun of the parasites of this Scale-insect which occurs commonly at Pusa on *Citrus* spp. and Roses, but very few parasites could be obtained.

A large amount of *Lecaniinæ* material was collected with a view to finding any parasites which might be of use in the control of *Coccus viridis* (*Lecanium viride*) in the Coffee Districts of Southern India, but it was found that the majority of the local *Lecaniinæ* were free from Chalcid parasites ; only those scales found on *Ficus religiosa* and *Ricinus communis* were parasitized to any extent.

Parasites of Aleurodids.—As noted in last year's report, attempts have been made to procure a parasitized colony of *Aleurodes citri* for export to Florida. The parasite which attacks *A. citri* on *Jasminum* is the same as the one which attacks *A. ricini* on castor, and castor plants were therefore grown and infected but unfortunately became heavily infested with *Tetranychus bimaculatus* and later on by a leaf-fungus and the plants therefore had to be rejected. A very similar parasite attacks another *Aleurodes* on *Ficus* and trials with this are also being made.

Economic Aleurodidæ.—Life histories of *Aleurodes cirtri*, *A. bergi*, and *A. ricini* were completed.

Pyrilla aberrans.—The complete life history of *Pyrilla aberrans* was worked out during the year and repeated thrice to check the period of a life cycle. Chalcid, Dryinid and Stylopid parasites were also reared, some of these being new. It may be noted that three species of *Pyrilla* (*P. aberrans*, *P. perpusilla* and *P. pusana*) are found on sugarcane at Pusa, all formerly confused under the first name.

Nephotettix bipunctatus.—Much time was given to the outbreak of *Nephotettix bipunctatus*, the Rice Leaf-hopper (locally called " Maho ") in the Central Provinces. This insect was first reported as a pest from the Sati State in the Bilaspur District of the Central Provinces. A Fieldman was sent to make investigations on the pest and to try measures suggested from Pusa. These measures consisted of (1) bagging with large field bag-nets, (2) bagging with hand-nets, (3) brushing over the infested fields with a rope dragged over the plants, (4) oiling the infested fields with kerosine and then dragging a rope across so as to submerge the plants temporarily, (5) spraying with contact insecticides, and (6) putting up lantern traps in the affected fields. Of these it was found that the last was the most efficacious and that most readily adopted by the cultivators.

A leaflet on this pest in English and Hindi was written and issued by the Department of Agriculture, Central Provinces, and widely circulated amongst the cultivators of the affected Districts. It has also been translated into Uriya and issued by the District Board in Balasore, where an outbreak of *Nephotettix* also occurred. A trained Fieldman was lent to the Central Provinces to carry on continuous observations of the pest and to advise adoption of remedial

measures in the Raipur and Bilaspur districts which were severely infested last year.

Life-histories of Indian Insects.—In the Insectary were reared some two hundred insects which had not been reared previously. Considerable attention has been paid to various insects (mostly Coleoptera) found at and just below soil-level and about sixty different beetles have been reared and their breeding-places, earlier stages, food and habits noted. Many of these beetles are predaceous and are therefore beneficial by destroying plant-feeding crop-pests ; amongst such may be noted an unidentified Carabid predaceous on a Cydnid bug, a species of *Chlaenius* predaceous both in the larval and adult stage on caterpillars of *Utetheisa pulchella* and several Elaterid beetles. Of these last a single grub of *Agrypnus* sp. ate more than 200 Scarabæid grubs in the course of about three months, and another Elaterid larva was found to exercise a considerable check on Tenebrionid grubs feeding at the roots of gram and other crops.

A point, which has been observed with regard to some common insects (*Laspeyresia, Chilio, Chloridea*) reared for observation of exact cycles of their life-history, is that out of the same batch of larvæ, feeding and commencing to hibernate at the same time, some hibernate and emerge as adults whilst others hibernate during the cold weather, then æstivate during the hot dry season and emerge at irregular intervals thereafter as late as July or August. From the practical point of view of control this is of some importance, as measures taken on the first appearance of the insects after hibernation may be rendered abortive, or will at least require to be supplemented, in view of these later emergences. An observation of this kind, apparently trivial in itself, emphasizes the fact that an intimate knowledge of the habits of the insects concerned must be the first step towards their control.

Crocidolomia binotalis is a cold-weather pest of Cruciferæ. Unsuccessful attempts were made to find out how it passes through the rest of the year.

Zonabris pustulata is an extremely common black and red Blister Beetle whose-life history is yet unknown. Eggs were obtained in November 1914 and hibernated in the soil, hatching at the end of the cold weather, but all attempts to get the young larvæ to feed on egg masses of various grasshoppers proved unsuccessful, and the grubs could not be reared. Dr. Roepke, of the Experimental Station at Salatiga in Java, has recently informed me that he found larvæ of this species feeding on egg masses of *Cyrtacanthacris* ; it is probable that this beetle has a similar habit in India.

Another failure was encountered in further attempts to obtain the life-history of *Anthia sexguttata*, a giant Carabid which feeds in the adult state on practically any insects it is able to catch.

A Bruchid beetle (*Bruchus affinia*) was observed to lay eggs extensively on pea-pods at Pusa in January and February, so that the peas may be infected in the field before being stored. These seeds have been

treated and stored in various ways to ascertain the extent of damage and how it can best be checked.

An unindentified Dermestid beetle in stored wheat has been found to complete its transformation in from one to two years.

Further observations have been made on the life-history of *Odoiporus longicollis*, a weevil which bores in plantain stems, and the life of the adult beetles has been found to extend to a period of up to two years.

With reference to the campaign against *Agrotis ypsilon* at Mokameh it was not known how this insect passes through the hot weather and rainy season in the Plains of India. Large numbers were therefore obtained in March and it has been found that, under conditions in the Insectary, continuous broods have been obtained, which suggests that it may breed somewhere in the vicinity of the areas attacked in September-December.

The status of *Tenebroides mauritanicus* as a grain-pest having been doubt ful, this was ascertained by experiments, by which it was found that this beetle and its larva certainly can and do eat wheat and rice grains, preferring wheat to rice. The adult beetle preys upon the adult Rice Weevil, *Calandra oryzæ* so that in grain affected by *C. oryzæ* the presence of these beetles is beneficial as, when present in sufficiently large numbers, they will ultimately rid the grain of the weevils although they themselves will eat a small proportion of the grain; but the resultant loss will be less than if the weevils bred unchecked. Further experiments will be undertaken with this insect.

Batocera rubus, a longicorn beetle commonly boring in fig, mango, etc., has been reared from the egg and the complete life-cycle observed to occupy a year.

Balaninus calbum has been traced throughout the year, though not reared from eggs. The life-cycle occupies a year.

Complete life-cycles have been observed of *Plotheia celtis, Porthesia xanthorrhœa, Perigea capensis, Spodoptera mauritia, Liogryllus bimaculatus, Terias hecabe, Hypolimnas bolina, Euplœa core, Junonia orithiya, Huphina nerissa, Papilio polytes* and *Deilephila nerii* and further observations have been made on numerous other insects.

Fruit-flies have been reared in large numbers—in thousands in some cases—from various fruits in order to procure parasites and to ascertain the proportion parasitized. In the case of *Bactrocera cucurbitæ* the results have been disappointing as parasites were very few and it is perhaps owing to this fact that this Fruitfly does so much damage to cucurbitaceous vegetables. Only in one lot of fruits of *Momordica charantia* were the maggots found to be attacked by a Braconid parasite to the extent of about 16 per cent., and even this parasite was not found to be present throughout the year. The Peach-Flies (*Bactrocera zonata*) showed an insignificant percentage of parasitism and the parasitic grubs were observed to remain in a resting condition throughout the remainder of the year.

Carpomyia vesuviana was reared from fruits of Ber (*Zizyphus jujuba*) and was found to be extensively parasitized. Attempts will be made, at the request of the Royal School of Agriculture at Portici, to introduce this parasite into Italy, whence this Fruitfly was originally described, its specific name being derived from the fact that the original specimens were taken on the slopes of Mount Vesuvius. The flies remain in the pupal state for some time, from about February to June or later, but the parasites emerge about March and probably have an alternative host.

In order to test the effect of poisoned sprays on fruit-flies long series of flies reared in the Insectary were fed with a solution composed of Lead Arsenate $2\frac{1}{2}$ to 5 oz, Gur $2\frac{1}{2}$ lbs., and water 4 gallons, and it was found that a strength of 3 to 5 oz. of Lead Arsenate kills the flies in about 36 hours.

A Braconid parasite of *Diacrisia obliqua* was bred for a generation to note its life-cycle and rate of increase and some work was also done on an Ichneumonid parasite of *Spodoptera mauritia.*

Odontotermes assmuthi, the largest of the five Termites known to occur at Pusa, has been under observation for the last four years. From the emergence of adults which took place in July 1914 several observations nests were established in the Insectary and new colonies were successfully started and soldiers and workers reared. This is the first time, so far as I am aware, that any species of the true earth-dwelling *Termitidæ* has been reared from the egg to any adult stage under observation, although some of the wood-living *Protermitidæ* and *Mesotermitidæ* have been reared in Europe. Further colonies are now being reared.

Illustrations were prepared, to the extent of artistic assistance available, of the insects studied during the year. Coloured plates, showing the complete life-history, were prepared during the year of the following insects :—*Utethesia pulchella,* Odoiporus longicollis,* Atractomorpha crenulata, Oxycarenus lætus, Plusia orichalcea, Perigea capensis, Etiella zinckenella, Clyphodes indica,* and *Chilo Simplex,** of which those marked * are printed and available. Numerous line drawings have also been made and will be utilized as occasion arises. The issue of coloured plates and lantern slîdes has been continued.

Insecticides.—Experiments in the preservation of wood against attack of Termites (white ants, so called) were continued, the species of Termite experimented with being *Microtermes obesi* (anandi), which is apparently a common species throughout the Plains of India. " Powellized " wood, supplied by the Agents for testing has failed almost wholly within four years. " Sideroleum ", tested as a preservative of wood against Termites, has also failed ; further tests will be made of it. Testing of " Microlineum " as a preservative has been started.

Creosote was tried to make sugarcane setts immune to Termites without interfering with germination, but these experiments failed.

Stored Grain Pests.—A series of experiments on the preservation of rice, wheat and pulses against insects under stored conditions has been commenced

on a small scale. The methods found most effective will be tested on a larger scale.

Silk-worms.—The univoltine mulberry silkworm eggs, which were sent to Shillong and Muktesar for rearing in March, gave satisfactory results but those sent to Muktesar for rearing in October did not hatch properly as the natural temperature of the place from July to October was not sufficiently low. Our attempts to establish a superior stable multivoltine hybrid race which would not degenerate, were continued. Mulberry silkworm eggs were supplied to 171 rearers and Eri eggs to 144 applicants, and mulberry and castor seeds to 20 applicants. One Fieldman and a rearer were sent to Jeolikote, Kumaun for rearing Eri worms in April and May as it is difficult to procure a fresh stock of eggs for distribution in June and July. Thirty-one pounds of Eri cocoons were supplied to Messrs. Inagaki & Co. of Kyoto for testing in the Mills of Japan. Difficulty was experienced by the rearers in disposing of Eri cocoons in small lots. Silk exhibits were sent to Exhibitions held at Muzaffarpur, Monghyr, Pudukottai, Mysore and to Calcutta, Madras and Cawnpore in connection with the Exhibition of Indian as contrasted with German and Austrian goods. The Secretary of the Mysore Dasara Exhibition awarded a silver medal for the exhibits. Eighteen silk pieces were loaned to the Director General of Commercial Intelligence, Calcutta, for the Exhibition of Indian as contrasted with Enemy Goods. Eight sets of Silk exhibits were sent to the Superintendent, Central Seed-store, Bengal, Sibpur. His Highness the Maharaja of Darbhanga took a keen interest in all the operations of the industry during His Highness's visit to the Institute. Instruction was given by correspondence in silk-dyeing, bleaching, silkworm rearing, reeling and spinning.

In Madras the silk work has been concentrated in one village near Kollegal. Disease-free seed was raised and sold to the raiyats under guarantee, and the subsequent rearing watched and advice given when needed ; the results from this brood were good. There was also some demand for cocoons of this brood, Rs. 2-8 per thousand being paid for them, or one rupee above the normal market price. That good stock is required and will be bought if available is shown by the above figures and by the fact that, out of 38,000 diseased eggs found in seed examined by the Sericultural Fieldman at Kollegal, no less than 29,500 were found to be infected with Pebrine ; these eggs were nearly all bought from Mysore dealers and these figures show how Pebrine is being disseminated through the villages and threatening the existence of the silk industry in this district. Experiments made with Univoltine eggs obtained from France were unsuccessful but these will probably be tried again under different conditions.

In the Punjab one hundred and sixty-five ounces of Mulberry silkworm eggs were distributed, mostly at the rate of one ounce per family. The results of rearing from 141 ounces of this seed are available, amounting to 23 maunds and 8 seers of dry cocoons, which were sold for Rs. 1,862-10-3 at the annual silk-cocoon exhibition held at Gurdaspur.

In the United Provinces Mr. Akhtar Mohammad Khan remained during the year on special duty in connection with the Eri-silk industry.

Lac Work.—During the past year emergence of larvæ took place at Pusa on the 28th September 1914 and 10th June 1915 and in the two seasons 120 Ber trees were inoculated. Brood-lac was supplied to seven persons. Specimens of lac from two new food-plant which were not hitherto recorded were received from the Honorary Secretary, Agri-Horticultural Society of India, Calcutta, and the Economic Botanist, Lalbagh, Bangalore. Parcels for sending in lac specimens were sent only to such Forest Officers from whose Division or Range the series of specimens was not complete. Unfortunately serious gaps occurred in the past and these have not been filled up as yet.

Five tubs containing Kusumb (*Schleichera trijuga*) plants were inoculated and despatched to Mr. N. Fujii, Hozan, Formosa, through the Consul General for Japan, Calcutta.

Apiculture.—During the year experiments with the Indian Bee (*Apis indica*) were continued at Pusa, special attention being paid to the three principal defects of this bee in the Plains, *viz.*, (1) deserting the hive in Autumn, (2) inability to defend the hive against Wax Moth, this being one of the causes which lead to desertion, and (3) frequent swarming.

The results obtained this year go to show that the bees can be prevented from deserting the hive and a little care prevents the Wax Moth, a well-made hive being of great help in this direction. A little care bestowed on these bees leads to an increase of the population in the colony but stimulates swarming. Efforts made at checking swarming were not successful. It appears that the old principle of inducing swarming early in the season so as to have a number of colonies from which to take surplus honey in the honey season, will be more suitable to these bees than the new principle of checking swarming and having larger surpluses from strong and populous colonies. The work will be continued. A Bulletin on Bee-keeping was issued at the close of the year.

Insect Survey.—Steady progress has been made in additions to and arrangement of the Collection. The whole of the collection of *Hymenoptera* has been re-arranged in one series, so that all the information on any species or group is now available in one place. The same is being done with the Coleoptera, and other groups will be taken up as time and staff permit. The following collections were sent to specialists in the groups named and our thanks are due to them for the help afforded :—Chalcididæ to Dr. L. O. Howard, Formicidæ to Mr. W. M. Wheeler, Stylopidæ to Mr. Dwight Pierce, Dryinidæ to Mr. J. C. Crawford, Rhynchota to Mr. W. L. Distant, Coccidæ to Mr. E. Ernest Green, Noctuidæ and Pyralidæ to Sir George Hampson, Rutelidæ, Cetoniadæ and Dynastidæ to Mr. C. J. Arrow, Carabidæ to Mr. Andrews, Histeridæ to Mr. George Lewis, Curculionidæ (part) to Mr. G. A. K. Marshall, Lucanidæ to Mr. F. H. Craveley, Microlepidoptera to Mr. E. Meyrick, Trypaneidæ

to Professor M. Bezzi and their parasites to Professor Silvestri, and various Diptera to Mr. E. Brunetti.

II.—Work in the Provinces.

Madras.—In Madras some thirty-five parcels of Insect specimens were sent in during the year with requests for advice in dealing with insect pests and demonstrations in destroying crop pests were given in Malabar, Kilacheri and Puducheri. An extensive campaign against the Deccan Grasshopper (*Colemania sphenarioides*) in the Bellary District was planned, but owing to climatic causes the outbreak in 1914 was insignificant. Experiments in control of Mango Hoppers (*Idiocerus*) were made in the Salem District, the trees being sprayed with Crude Oil Emulsion and with Fish Oil Soap made by the Fisheries Department, and successful results were attained. Prolonged experiments with Light-traps for the control of Paddy Stemborer (*Schœnobius*) showed that other means must be sought for combating this most serious pest; this result, it may be added, is identical with that reached at Pusa and in Bombay. A series of experiments was undertaken, and is still in progress, at the Government Sugarcane Farm at Chettipalayam, with a view to testing various methods of preventing damage to cane setts by Termites. Trials of various insecticides have been made, and experiments have also been made on control of insect pests by means of baits.

The general collection has received considerable additions and considerable progress has been made in the arrangement and identification of the specimens of insects. Life-histories of the following insects have been studied :—*Calocoris augustatus*, *Megacœlum stramineum*, unnamed Capsid on Sorghum, *Pundaluoya simplicia*, Anthomyiad Flies on (1) Sorghum, (ii) Cumbu and Panivaragu and (iii) rotting fruit, Cecidomyiad Flies on (i) Sorghum, (ii) Cumbu and (iii) Paddy, Cotton Aphis, *Parasa lepida*, *Schœnobius bipunctifer*, *Amsacta albistriga* and *A. moorei*, *Eupterote mollifera* and *Adisura atkinsoni*, attention being concentrated as far as possible on insect pests of cereals.

Bombay.—In Gujarat light-traps were found fairly successful in the control of *Amsacta moorei*, 9,062 moths, of which 1,732 were egg-laden females, being caught in about three weeks, with the result that the succeeding attack by caterpillars was insignificant. The moths and egg-masses were also handi-picked but few were obtained by this method. Trials of Ammonium Sulphate, Kainit, and Salt were made against *Microtermes gloibicola* attacking groundnut, but the results were inconclusive. The regular picking and destruction of first-attacked shoots was found successful in preventing attack of Cotton bolls by Earias. Fumigation of burrows with Sulphur by means of a Universal Ant Exterminator was found successful in the case of an outbreak of Gerbilles. A small invasion of Locusts in 1914 laid eggs in the Ahmedabad District and in Idar State, but prompt destruction of the young hoppers averted damage to crops.

Spraying with Lime and Sulphur was found successful against Mites on *Sorghum* in the Surat District, but it is doubtful whether this method could be applied over any large area. Some experiments were done on the preservation of seeds from insects attack and the results indicate that thorough drying in the Sun for three days or fumigation with Carbon Bisulphide gave the best result.

Show-cases of Insect Pests and Control-methods were exhibited at eleven Agricultural Shows in Gujarat, Khandesh and Ahmednagar. Show cases of Crop-pests were also prepared for the Agricultural Farms in Gujarat and Khandesh.

Central Provinces.—The chief event during the year was the outbreak of "maho" (*Nephotettix bipunctatus*), referred to under Section I of this Report. Borers in Sugarcane were also studied and of these *Scirpophaga* is the worst pest, but experiments on the Sindewahi Farm have proved that its ravages can be reduced to a minimum by planting cane in October and November instead of in February and March as has been the practice hitherto.

United Provinces.—Successful experiments were made in the storage of seed wheat by the use of Naphthaline. Experiments in potato storage and demonstrations of methods to prevent loss by potato moth were also carried out.

Punjab.—*Attagenus undulatus* is the most important of the insects infesting stored wheat and its life history was worked out. Borers in sugarcane and maize were collected and the removal of "dead-hearts" in young canes was found satisfactory as a control measure. The year 1914 was not a "Bollworm" year in the Punjab and there was no demand for the parasites, but these were bred in 1915 and established in the breeding-plots at Lyallpur by the help of early supplies of living material sent from Pusa.

Bihar and Orissa.—Special campaigns were conducted against Greasy Surface caterpillar on rabi crops on the chaur lands at Mokameh, Colgong and Ghogha. As regards Potato Moth (*Phthorimœa operculella*), the most serious insect pest of stored potatoes, it was thought advisable to discontinue the storing demonstrations in the season 1914 as the effectiveness of the recommended method of storing had been satisfactorily demonstrated for several years successively to the interested cultivators at the important centres of potato cultivation in the Province. The results of the major campaign against insect pests, conducted during the year under report, are summarized below :—

The campaign against *Agrotis ypsilon* which is a regular pest of Rabi pulses at Mokameh, was conducted with 34 Andres Maire traps which had been fitted with some improvements during the previous season. The improvements were found to be very effective. The total number of moths caught during the season was 4,34,726 of which 176,843 were females and 257,883 males. As there was no distinct first brood attack, picking was not done. As a result of

the abnormally droughty conditions prevailing during the season the germination was generally poor and the stand of crop unsatisfactory. The extent of damage done by *Agrotis* was 2,000 bighas. A second campaign was conducted against the same pest at Ekchari and Taurar (District Bhagalpur) with 24 improved Andres Maire traps. 52,777 parent moths were destroyed during the season of which 27,681 were females and 25,096 males and 143,754 caterpillars of the first brood were picked off and destroyed. The extent of damage due to *Agrotis* at Ekchari was 12 bighas while at Tautar it was 153 bighas. Drought was responsible for the damage on 34 bighas at Ekchari and 418 bighas at Taurar. The total cost of campaign on account of the temporary staff and contingencies was Rs. 430-13-1 of which Mr. Mailing Grant paid Rs. 138-1-0 for the expense at Ekchari.

Though the potato storing demonstrations were discontinued the Department continued giving advice to the cultivators as regards the best method of storing potatoes. As a result of the Department's work 1,858 koeries stored 165,543 maunds of potatoes under sand round Patna and Bankipur during the year under report and at Bihar 754 koeries stored 20,913 maunds or 183 per cent. in excess of the amount stored in the previous season. The table below will show the increasing popularity of the recommended method among the cultivators of the Patna District.

Year.	Patna.		Bihar.	
	Number of persons storing.	Maunds stored.	Number of persons storing.	Maunds stored.
1910 . . .	6	122	..	..
1911 . . .	200	8,431	..	..
1912 . . .	399	16,613	27	302
1913 . . .	1,289	114,917	231	7,368
1914 . . .	1,858	165,543	754	20,913

Bengal.—The investigation of *Bhepu* disease of paddy was continued and found to be due to the attack of a Cecidomyia fly (probably *C. oryzæ*, Wood-mason). Experiments to check Mango Weevil by kerosine treatment were carried out and the results seem promising. Spraying demonstrations were also carried out against Red Spider on ganja.

Burma.—Thirty-eight lots of insect pests of various crops were reared during the year from specimens collected by the Entomological Assistant or sent in by inquirers. Special attention was paid to insect pests of paddy, of which *Schoenobius, Cirphis unipuncta, Hispa armigera, Leptocorisa*, and *Paranara mathias* were most in evidence during the year. Experiments were done with various insecticides and other means of control of crop-pests, and also

with treatment of stored seeds. Tests of *Cajanus indicus* seeds, after treatment with Carbon Bisulphide, showed that their germination was not affected. Papers on the fumigation of seeds and on the Paddy Pests of Burma were prepared by the Entomological Assistant and read at the Half-yearly Departmental Conference held at Mandalay in December 1914.

List of Publications on Economic Zoology.

The following list contains those publications, actually issued during the year ended 30th June 1915, which deal with Indian Insects. This list is exclusive of publications issued by the Indian Museum and the Forest Research Institute and of papers on disease-carrying insects, as such will presumably be dealt with respectively by the Superintendent of the Indian Museum, the Forest Zoologist, and the Imperial Pathological Entomologist, nor does it include general publications on systematics, bionomics, etc., of Insects which are not Indian. For such the student, to whom these general publications are necessary, should consult the "Zoological Record."

AIYAR, T. V. R. . . The "Moon-Moth" (*Actias selene*) as a pest. (*Journ. Bomb. Nat. Hist., Soc., xxiii, 792-793*).

ANDREWS, E. A. . . Papers and Notes on Insects and Tea-Pests, (*Quart. Journ. of the Ind. Tea Association*).

ANSTEAD, R. D. . . Various Notes on Insect Pests and Insecticides. (*Planters' Chronicle.*)

ARROW, G. J. . . Some Further Notes on Lamellicorn Beetles of the Subfamily *Dynastinæ*. (*Ann. Mag. Nat. Hist.* (8) *xiv 257-276*).

" . . . Notes on the Coleopterus Family *Dermestidæ*. (*Ann. Mag. Nat. Hist.* (8) *xv, 425-451*).

ASSMUTH, J. . . Indian wood-destroying White Ants. (*Journ., Bomb. Nat. Hist. Soc., xxiii, 690-694*).

BAGNALL, R. S. . . Brief descriptions of new Thysanoptera—IV and V (*Ann. Mag. Nat. Hist.* (8) *xiv, 375-381, xv, 315-324*).

BASU, B. C. . . Report on the Silk Industry of Assam (Assam Government Press).

BELL, T. R. . . The Common Butterflies of the Plains of India. (*Journ., Bomb. Nat. Hist. Soc., xxiii, 481-497*).

BEZZI, M. . . . Indian Pyrgotinæ (*Ann. Mag. Nat. Hist.* (8) *xiv, 153-163*).

Bezzi, M. . . .	Two new species of Fruit Flies from Southern India (*Bull. Entl. Research, v, 153-154*).
Blair, K. G. . .	Notes on Coleoptera of the genus *Azarelius*). (*Ann. Mag. Nat. Hist.* (*8*) *xiv, 315-316*).
Bolivar y Pieltain, C.	Eumastacinos nuevos ó poco conocidos (*Trabajos del Museo Nac. de Cienc. Nat. Madrid, Serie Zool. Num. 16*).
Burr, M. . . .	Notes on the *Forficularia*. XXIII.—More new species. (*Ann. Mag. Nat. Hist.* (*8*) *xiv, 420-428*).
Chapman, T. A. . .	An analysis of the species of the genus *Curetis*. (*Nov. Zool. xxii, 80-104*).
De, M. N. . . .	Instructions for rearing Mulberry Silkworms. (Bengali edition). (*Pusa Bulletin No. 39*).
,, . . .	How to improve Silk-reeling in Bengal. (*Pusa Bulletin No. 44*).
,, . . .	First Report on the Experiments carried out at Pusa to improve the Mulberry Silk Industry. (*Pusa Bulletin No. 48*).
Distant, W. L. . .	Rhynchotal Notes, LV. (*Ann. Mag. Mat. Hist.* (*8*) *xiv, 323-333*).
,, . . .	A few undescribed Rhynchota. (*Ann. Mag. Nat. Hist.* (*8*) *503-507*).
Dracott, C. H. . .	Notes on Cicada. (*Journ., Bomb. Nat. Hist. Soc., xxiii, 379-380*).
Dutt, H. L. . .	Potato Tingid (*Recaredus* sp.). (*Bihar Agric. Journ., Vol. ii*).
,, . . .	Potato Storage Work in Bihar and Orissa in 1913 (*Fourth Report*). (*Bihar Agricl. Journal, Vol. ii*)
Ellis, E. V. . .	A new *Penthema* from Burma. (*Journ., Bomb. Nat. Hist. Soc., xxiii, 585-586*).
Evans, W. H. . .	Notes on Indian Butterflies. (*Journ., Bomb. Nat. Hist. Soc., xxiii, 302-310*).
,, . . .	Butterflies caught in South East Tibet. (*Journ., Bomb. Nat. Hist. Soc., xxiii, 532-546*).
Field, F. . . .	Habits of *Sceliphron coromandelicum*. (*Journ., Bomb. Nat. Hist. Soc., xxiii, 378-379*).

FLETCHER, T. B. . Note on Tiger Beetles from Coorg. (*Journ., Bomb. Nat. Hist. Soc., xxiii, 379*).

,, . . . Some general methods of controlling attacks by Insect Pests; Agricultural Methods; Mechanical Methods. (*Madras Agricl. Dept. Leaflets Nos. iii and iv of 1914*).

,, . . . Practical Instructions for the Kollegal Mulberry Silkworm Rearers. (*Madras, Agric. Dept. Leaflet No. 1 of 1914*).

,, . . . Some South Insects. (Madras Govt. Press, Imperial 8 vo., pages xxii+565, 50 plates and 440 text-figures.)

FRYER, T. C. F. . . A Note on *Argynnis castetsi*. (*Journ., Bomb. Nat. Hist. Soc., xxiii, 587-588*).

GHOSH, C. C. . . Bee-keeping. (*Pusa Bulletin No. 46*).

KARNY, H. . . Ein neues Blattiden-genus aus Assam. (*Entm. Mitteilungen, ii, 250*).

LEWIS, G. . . . On new species of Histeridæ. (*Ann. Mag. Nat. Hist. (8) xiv, 283-289*).

MARI, W. . . . Sericulture in Mysore. (*Mysore Govt. Press*).

,, . . . Rational Sericulture. (*Mysore Govt. Press*).

,, . . . Report on work during 1914. (*Mysore Economic Conference Leaflet*).

MARSHALL, G. W. K. Some Injurious Indian Weevils. (*Bull. Ent. Res. v, 377-380*).

MARTIN, A. F. . . The Butterfly *Argynnis castetsi* in Travancore. (*Journ., Bom. Nat. Hist. Soc., xxiii, 791-792*).

MEADE-WALDO, G. & MORLEY, C. Notes and Synonymy of Hymenoptera in the collection of the British Museum. (*Ann. Mag. Nat. Hist. (8) xiv, 402-410*).

MEYRICK, E. . . A new moth parasitic on Spiders. (*Entl. Mo. Mag. 1914, 219-220*). (*Brachmia xerophaga* in nests of *Stegodyphus sarasinorum* in S. India).

,, . . . Exotic Microlepidoptera. (Numerous Indian species described as new).

MISRA, C. S. . . The Cultivation of Lac. (Hindi edition). (*Pusa Bulletin No. 28*).

MISRA, C. S. . . Maho (*Nephotettix bipunctatus*). (*Central Province Agric. Dept. Leaflet in English and Hindi ;* also issued in Uriya by the Balasore District Board).

PIERCE, W. DWIGHT . Descriptions of two new species of Strepsiptera parasitic on Sugarcane Insects. (*Proc. Entl. Soc. Washington, xvi, 126-129*).

PRELL, H. . . . Beitrage zur Kenntniss der Dynastinen. X. (*Entom. Mitteilungen, iii, 197-226*).

ROTHSCHILD, LORD AND JORDAN, K. Thirteen new Sphingidæ. (*Nov. Zool. xxii, 281-291*).

,, . . . Some new Sphingidæ in the Collection of the British Museum. (*l. c. 291-294*).

SCOTT, H. . . . On some Oriental Nycteribiidæ. (*Ann. Mag. Nat. Hist.* (8) *xiv, 209-235*).

SEN, P. C. . . . The Palm Leaf Caterpillar (*Nephantis serinopa* Meyr.). (*Bengal Dept. Agric. Leaflet No. 1 of 1915*).

SHROFF, K. D. . . The Silk Weaving Industry of Amarapura. (*Agric. Journ., India, ix, 254-287*).

SPAETH, F. . . Neue Cassidinen aus Yunnan. (*Entom. Mitteilungen, iii, 226-230*).

STEBBING, E. P. . . Indian Forest Insects of Economic Importance. Coleoptera. (London ; pp. xvi+648, 63 plates and 401 Text-figures).

SUVOROV, G. . . New species of *Stephanocleonus* and *Catapionus* (Curculionidæ). (*Rev. Russe d'Entom, xv, 109-114*). [In Russian ; two species from Tibet are described as new].

TURNER, R. E. . . Notes on Fossorial Hymenoptera XII. (*Ann. Mag. Nat. Hist.* (8) *xiv, 245-257*).

TYTLER, H. C. . . Notes on some Butterflies from Manipur. (*Journ., Bomb. Nat. Hist. Soc., xxiii, 216-229, 502-515*).

WARREN, W. . . New Palæarctic and Eastern *Noctuidæ* in the Tring Museum. (*Nov. Zool., xxii, 147-153*).

,, . . . Some new Oriental *Cymatophoridæ* in the Tring Museum. (*l. c. 154-159*).

,, . . . New species of *Eutelinæ* in the Tring Museum. (*Nov. Zool. xxi, 276-280*).

WARREN, W. . . New species of *Drepanulidæ, Noctuidæ* and *Geomitridæ* in the Tring Museum. (*l. c., 401-425*).

WEBB WARE, F. C. . Locusts in Baluchistan. (*Agric. Journ. India, x, 159-166*).

WOODHOUSE, E. J. AND DUTT, H. L. The Campaign against Surface Caterpillars at Mokameh (Fourth Report). (*Bihar Agric. Journ., Vol. ii*).

(ANONYMOUS) . . Instructions for collecting and forwarding specimens of Insects damaging crops. (*Assam Dept. Agric. Leaflet No. 2*, in English, Bengali, Assami and Khasi).

Part II.—Forest Entomology.

BY

C. F. C. BEESON, B.A., I.F.S.,

Forest Zoologist.

Sal Insects.—(*a*) *Investigations in Bengal.*—The enquiry as to the connection of insects with the dying off of *sal* in Buxa and Jalpaiguri Divisions was carried out in December-January 1914-15 and satisfactory conclusions were arrived at. About twenty species of borers were commonly found in dying trees, but their importance as factors causing death was determined to be secondary in all species except one. In particular the species *Diapus furtivus* to which the damage was originally assigned, has been established as a secondary borer of minor importance. A percentage count of infested trees showed a preponderance of certain species in the following proportions :—

		Per cent.
1. Trees with insects absent at time of death		36
2. Trees with insects present at or shortly after death.		
(*a*) *Hoplocerambyx spinicornis*, Newm.	30	64
(*b*) *Diapus furtivus*, Samps.	16	
(*c*) *Xyleborus major*, Steb.	5	
(*d*) Either of the above species accompanied by some or all of the following. *Sphaerotrypes siwalikensis*, Steb. *Xyleborus fallax*, Eichh. *Xyleborus andrewesi*, Bldfd. *Platypus curtus*, Chap. *Diapus 5-spinatus*, Chap.	13	
		100

In addition the following species occurred commonly, but in nearly all instances as late arrivals :—*Xyleborus laticollis*, Bldfd. *X. parvulus*, Eichh. *X. perforans*, Woll. *X. schlichii*, Steb. *X. semigranosus*, Bldfd. *X. submarginatus*, Bldfd. *X.* spp. n. *Eccoptopterus 6-spinosus*, Motsch. *Crossotarsus saundersi*, Chap. *C. bonvouloiri*, Chap. *Platypus cupulatus*, Chap. *P. solidus*, Walk. *Dialeges pauper*, Pasc. *Chlorophorus*, sp. n. *Xylotrechus buqueti*, Lap. et Gory.

Some of the above have not been recorded from *sal* previously. An examination of the roots of dead *sal* showed that in nearly every case they were attacked by a fungus. Whether the fungus is a true-root parasite and is the original cause of the death of the roots, or whether the roots are killed by some other agency and the dead tissues subsequently invaded by the fungus, has not been determined, but, as far as insect work is concerned, either case produces the necessary state of unhealthiness in the tree, which is essential for successful attack by borers. The species detailed above are therefore considered to be of secondary importance and incapable of attacking perfectly healthy trees. The heart-wood borer, *Hoplocerambyx spinicornis* is however a primary pest and indicates the need of precautionary measures.

A report on the enquiry has been drawn up and submitted together with suggestions for control measures to be adopted for *H. spinicornis*.

(*b*) The life history of *H. spinicornis* has been under observation in the Siwaliks Division, United Provinces, and the egg and early larval stages are being studied under insectary conditions at Dehra. The duration of the resting larval stage has been determined in Bengal and the United Provinces.

(*c*) The life histories (thirteen in all) of the shot-hole borers (*Ipidæ* and *Platypodidæ*) and of the small longicorns have been studied where opportunity offered, and a large amount of material collected. A note on the life histories of *Platypodidæ* of the *sal* and other principal timber trees is in course of preparation.

Teak Insects.—(*a*) *The bee-hole borer.*—A report on the distribution and seasonal history of *Duomitus ceramicus*, Wlk., was drawn up and printed for circulation among forest officers in Burma, as a supplement to the existing Bulletin. No touring was done during the year in connection with the investigation, but the field-work was carried on by Mr. A. Rodger, Forest Research Officer, Burma, and the establishment of observation plots was commenced. The object of the observation plots is to determine the local annual incidence of the borer and the more important factors affecting it. Data will be collected during the next three years in these plots by the Research officer and such other officers as can be made available during the observation period.

Specimens of bee-holes and of larvæ of the borer have been received from several divisions.

(*b*) A study of the life history of the *Hepialid* borer, which makes reversed bee-holes in young poles, has been commenced. Specimens have been sent in from Myitkyina, Burma, S. Malabar, Madras, and Travancore.

(*c*) The longicorn beetle which is responsible for cankerous swellings and fissures on the stems of poles and saplings, has been identified as *Haplohammus cervinus*, Hope, from specimens taken in Upper Burma, Northern Shan States and Assam. The Divisional Officer, Chittagong Hill Tracts, sent a series of specimens of the work of this species.

(*d*) Three other species of longicorns have been bred out of Burmese teak, *i.e. Glenea galathea*, Thom. in Katha, *Nupshera variabilis*, Gahan. in North Toungoo, and *Xylotrechus quadripes*, Chevr. in the Northern Shan States.

Sundri Insects.—An investigation of insects attacking *Sundri* (*Heritiera Fomes*, Buch.) was undertaken in February in the Sunderbans. Boring beetles were found in freshly dead trees along the banks of *Khals*, and in wet depressions inland, but the roots and *shulas* of the trees were in every case diseased. No dying trees were met with in which primary insect infestation could be absolutely determined. The following insects were bred out, most proving to be new species and as yet unnamed.

Platypodidæ. *Crossotarsus squamulatus*, Chap., *Crossotarsus saundersi*, Chap. var., *Platypus* sp. n. (*Cupulati*); Ipidæ, *Cryphalus* spp. *Xyleborus schlichii*, Steb., *Xyleborus* spp., *Progenius* sp? *riehlii*, Eichh.; Cerambycidæ, *Gelonætha hirta*, Fairm.; Lamiidæ, *Glenea* sp. n. and one buprestid, three curculionids, and a siricid now being identified.

The *Platypodidæ* cause technical damage to the timber, which can be prevented in coupes by early immersion in water; the other borers do not appear to be of primary importance, but the investigation is being continued.

Chir pine insects.—(*a*) A note on the importance of *Ips longifolia* Steb. as a pest of *chir* regeneration areas was prepared for publication in the "Indian Forester." Touring in connection with bark-beetles of *chir* pine and other conifers was undertaken in Chakrata and Naini Tal Divisions, United Provinces, and experiments were started to determine the influence of elevation on the length of the life-cycles of the more important species.

(*b*) In Naini Tal Division progress was made with the scale insect investigation. Observation plots were established to watch the development of the disease and a large number of parasites collected, which are now being identified in Europe.

Toon-shoot borer.—The seasonal history of *Hypsipyla robusta* Mo. has been under observation in Dehra Dun. Sack-banding of the older trees during the first generation of the moth was tried as a control measure and proved successful. A combination of sack-banding with early pruning in plantations during the third generation should prove to be an efficient method of control for the borer, and operations will be commenced on these lines during 1916.

Miscellaneous pests.—Reports of pests and enquiries from forest officers have been more numerous than usual, and include several new records.

(*a*) The Divisional Officer, Rawalpindi, Punjab, reported damage by grasshoppers to *chir* seedlings in sowings. The specimens sent included species of *Aedalus*, *Chrotogonus* and *Teratodes*.

(*b*) From Kangra Division, Punjab, specimens of a defoliator of *Quercus incana* were received. The moth was identified as *Hypocala subsaturata*, Guen.

(*c*) The Divisional Officers, Bashahr, and Kulu, Punjab, sent in specimens of cock-chafer grubs which attack deodar seedlings.

(*d*) Damage to deodar by *Eccoptogaster major*, Steb. and *E. deodara*, Steb. in Madhan State was reported by the Divisional Officer, Simla, Punjab.

(*e*) The Divisional Officer, West Almora, United Provinces sent specimens of caterpillars of an unrecorded Lymantrid defoliator of *chir* pine.

(*f*) Specimens of insect damage to *kail* including that of *Cistelomorpha andrewesi*, were collected in Chakrata Division, United Provinces, by the Sylviculturist.

(*g*) *Derolus volvulus*, Fab. and *Glenea spilota*, Thom. were bred separately out of two consignments of *Bombax malabaricum* sent by the Divisional Officer, Kheri, United Provinces.

(*h*) One of the *sal* defoliators sent last year by the Divisional Officer, Gorakhpur, United Provinces, has been identified as *Plotheia celtis*, Mo.

(*i*) From Kalpi, Afforestation Division, Eastern Circle, United Provinces, reports of the attack of *Cœlosterna scabrator*, Fb., on babul seedlings were received.

(*j*) In South Vellore, Madras, an investigation of sandal borers was commenced by Mr. C. C. Wilson, Deputy Conservator of Forests, who bred out a new Lamiid as yet unidentified.

(*k*) The Conservator of Forests, Travancore, sent specimens of damage to sandal, including shoots and small branches infested with *Saissetia nigra*, Nietn. the black coffee scale.

(*l*) From South Kanara, Bombay, were received reports of damage in young Casuarina plantations by bark-eating caterpillars, *Arbela tetraonis*, Mo.

(*m*) The Khasya pine defoliators sent last year by the Conservator of Forests, Western Circle, Assam, and by Mr. A. N. David, Assistant Conservator of Forests, from the Jaintia hills were identified as *Metanastria repanda*, Wlk. Further specimens of frass and live caterpillers recently received appear to belong to two other species of Lasiocampidæ.

(*n*) Specimens of *Phœnix paludosa* attacked by a curculionid *Cyrtotrachelus* sp. were received from Pegu Circle, Burma.

(*o*) The Instructor, Burma Forest School, Pyinmana, sent specimens of *Aristobia approximator*, Thom. with a note that the beetles were eating the shoots of *Lagerstroemia Flos Reginæ* seedlings.

(*p*) The Executive Engineer, Pyinmana, Burma forwarded specimens of *Albizzia Lebbek* branches infested with various scale-insects including *Tachardia lacca*, and enquired for remedies.

Insect Collections.—The collections have been rearranged and expanded on removal to the new buildings and are now in good order. The chief additions include identified material returned during the year by various specialists, *viz.*, *Lucanidæ* and *Passalidæ* by Mr. F. H. Gravely, *Lamiidæ* and *Cerambycidæ* by Mr. C. J. Gahan, *Scarabæidæ* by Mr. G. Arrow, *Curculionidæ* by Mr. G. K. Marshall, *Ipidæ* and *Platypodidæ* by Col. Winn-Sampson, *Trypetidæ* and *Diopsidæ* by Mr. E. Brunetti, *Odonata* by Dr. Laidlaw, *Lepidoptera* and *Chrysomelidæ* by Mr. T. B. Fletcher, and a miscellaneous lot of specimens identified in Europe through Mr. E. P. Stebbing. In August 1914 there were fortunately very few consignments of insects in the hands of continental specialists and the losses due to the war are therefore small. They include *Psocidæ* with Dr. G. Enderlein, *Apidæ* with Dr. H. Friese, and *Tenebrionidæ* with Herr. H. Gebien in Germany, *Ipidæ* with Herr. H. E. Wichmann in Austria, and *Buprestidæ* with Capt. Ch. Kerremans in Belgium.

List of publications on Forest Entomology during 1914-15.

Stebbing, E. P.—Indian Forest Insects of Economic Importance, Coleoptera, London, 1914.

VETERINARY SCIENCE

By

A. W. SHILSTON, M.R.C.V.S.,

Assistant Bacteriologist in-charge of the Office of the Imperial Bacteriologist, Muktesar.

The following investigations was carried out during the year 1914-15 in the Imperial Bacteriological Laboratory, Muktesar.

Rinderpest.—A very large number of drugs was tested as to their effect on animals suffering from this disease. In view of the good results obtained with Iodine in the treatment of Haemorrhagic Septicaemia in cattle this drug was given an exhaustive trial. Treatment was commenced on the day that symptoms first developed and the drug was administered by a number of channels in various combinations. These included intravenous intramuscular and subcutaneous injections, as well as administration by the mouth and combined with Phenol, Ammonia and other agents either in olive oil or watery solution.

Although a small number of the treated animals recovered, the results were not constant and no appreciable effect could be claimed for any of the combinations of the drug. Other agents tested were Phenol, Camphor, Naphthaline, Pilocarpine, Benzoic Acid, Glucose, Arsenic and Magnesium Sulphate (subcutaneously), but without any good effect on the course of the disease being observed.

Experiments were made regarding the preservation of Rinderpest virus, this question being of importance in connection with the immunisation of cattle by the simultaneous method, these observations are being continued and a note will be submitted for publication shortly.

The length of time that sera will retain their protective values is a point of great importance and one on which frequent enquiries are received. Dr. Lingard showed that a prolonged exposure of Anti-Rinderpest serum in the Plains at shade temperatures ranging up to 126° F. caused a loss of 40 to 66 per cent. of its protective value. On the other hand, Holmes demonstrated that short exposure to temperatures up to 140° F. did not lessen the value of the serum. At temperatures below 90° F. Anti-Rinderpest serum will remain potent for at least two years, so that where arrangements can be made to keep it in a cool chamber such as a cellar or ice box, there is no objection to storing serum in the Plains in order that it may be available at short notice. This course has been followed at the Military Dairy Farms and some batches of serum that had been so stored for varying periods have recently been retested. Samples from three different brews of serum that had been kept at Lucknow,

Jubbulpore, and Ootacamund for periods of 12½, 17 and 19 months respectively, at temperatures varying from 50° F. to 60° F. were tested and it was found that in every case the potency was fully maintained.

Anthrax.— A long series of experiments were made on the effect of drugs in experimental Anthrax. Owing to the fact that the natural disease is frequently less rapidly fatal in Indian cattle than is usually the case with other breeds, opportunities for treatment might arise if a reliable curative agent could be found. The following compounds were tested :—

Tincture of Iodine B. P., Ammonium Iodide ; Sodium Iodide ; Arsenic Iodide ; Hydriodic Acid ; Iodine Trichloride ; Tinct. Iodi and Glucose ; Potassium Iodide and Glucose ; Potassium Iodide and Chlorine water ; Cinnamon oil ; Clove oil ; Peppermint oil ; Lemon Grass oil ; Iodipin.

Certain of the Iodine compounds exercised a decided effect on the disease but in no case were the results sufficiently conclusive to warrant their employment being recommended.

Hæmorrhagic Septicæmia.—A similar series of tests were made in the drug treatment of Haemorrhagic Septicæmia to those carried out in the case of Anthrax. Here again Iodine compounds had a marked effect but with no agent could better results be obtained than those previously recorded by Holmes. Attempts to confer immunity against this disease by drenching with living cultures of the causal organism were successful in a good proprotion of cases, but the experiments demonstrated that, when the cattle were in poor condition, the risk of giving them a fatal attack of the disease by this means was considerable so that the practical application of this method in India cannot be suggested.

Surra.—Observations on the treatment of Surra were continued and good results obtained by means of Arsenic and its compounds. The toxins of certain fungi were also tested but while the effect on the parasites "in vitro" in some cases was marked, the results of treatment were not encouraging.

Kumri.—The study of the pathology of this disease has been taken up by Dr. Macalister but no definite results have been arrived at.

Strangles.—A series of experiments regarding the employment of serum and vaccine for the curative treatment of young equines against strangles were carried out and results were encouraging but have to be confirmed during the ensuing cold season in one of the Remount Depôts.

Reports from Veterinary Colleges and Provincial Laboratories.

The Camel Specialist.—Mr. H. E. Cross published "A Note on Surra in Camels for Commandants of Camel Corps." In this the diagnosis and preventive and curative treatment of the disease are clearly described.

The annual report of the Camel Specialist for 1914-15 also contains, in addition to administrative details, particulars of experiments on the susceptibility of various animals to Camel surra, the treatment of surra in camel, tests of anti-fly preparations and the action of purgatives on the camel.

The Civil Veterinary Department, Bombay.—A pamphlet was issued describing Parasitic Gastritis in cattle sheep and goat—with methods of treatment and prevention.

The Civil Veterinary Department, North Punjab.—Mr. Meadows published an acccount of the Dhanni Breed of Cattle.

A list of papers published during 1914-15 bearing on Indian Diseases.

ACTON & KNOWLES . Rabies and anti-rabic treatment in India. (*Pamphlet of Pasteur Institute, Kasauli*).

BROWN, C. . . A large Salivary Calculus. (*Vety. Record, No. 1403, 1905, p. 604*).

CROSS, H. E. . . Experiments on the treatment of Surra in Camels. (*Mem. Dept. Agr., India, Vety. Series, ii, No. 6, 1914*).

,, . . . A note on Surra in Camels. (*Printed by the Supdt. Government Printing, Punjab*).

DEPARTMENTAL COMMITTEE. A Report of the Departmental Committee appointed by the Board of Agriculture and Fisheries to inquire into Foot and Mouth Disease, 1914.

GAIGER, S. H. . . A Revised Check List of the Animal Parasites of Domesticated Animals in India. (*Journ. Comp. Path. and Ther., xxviii, 1915, pp. 67-76*).

GANGULY, H. C. . . Polycystic Kidney in a Buffalo. (*Vety. Record, No. 1369, 1914, p. 199*).

,, . . . Cæsarean Section in a Cat. (*Vety. Journal, Vol. lxx, 1914, p. 589*).

HOLMES, J. D. E. . Some Experiments on the Immunising Effect of the Simultaneous Injection of an Anthrax Attenuated Virus and an Anthrax Anti-Serum. (*Mem. Dept. Agric. India, Vety. Ser., Vol. ii, No. 7, 1914*).

MEADOWS, D. . . Report on the Dhanni Breed of Cattle. (*Dept. Agric. Punjab*).

LANE, CLAYTON . . Bursati Nematodes from the Indian Elephant. (*Indian Jour. Med. Research, ii, 1914-15, pp. 380-398*).

MITRA, S. N. & GANGULY, H. C. Canine Filariasis. (*Vety. Jour., Vol. lxxi, pp. 40-42*).

MITTER, S. N. . .	Contagious Ophthalmia among Cattle. (*Vety. Jour.. Vol. lxxi, p. 28*).
„ . . .	A Tumour at the Base of an Antler of an Indian Spotted Deer. (*Vety. Record No. 1379, 1914, p. 320*).
„ . .	On a peculiar form of *Pasteurella* in an Indian Elephant. (*Centralbl. f. Bakt. I Abt. Orig. 1914, Bd. lxxiii, pp. 12-13*).
OLIVER, E. W. . .	Preliminary note on Sheep-breeding experiments (*Civil Vety. Dept., United Provinces*).
SMITH, A. & MITTER, S. N.	A brief note on an outbreak of Septicæmia among the Monal Pheasants of the Calcutta Zoological Garden. (*Vety. Jour., Vol. lxxi, pp. 37-40*).

MEDICAL RESEARCH.

The following brief account of medical research during 1914-15 has been compiled from the Report of the Scientific Advisory Board of the Indian Research Fund Association. During the year research work has been considerably hampered by the recall to military duty of several medical officers. None the less decided progress has been made in the investigations of various subjects referred to below.

Cholera.—The investigation into the causes and conditions of and means of combatting this disease has been conducted by Major E. D. W. Greig, C.I.E., I.M.S., who has published several reports on his researches. Perhaps the most important results attained are concerned with the invasion of the tissues by the cholera vibrio and the lesions of the biliary passages. Light has been thrown on the production of cholera " carriers," which probably play an important part in the spread of infection. Other important observations deal with the possibility of destroying the cholera vibrio in the gall-bladder by means of urotropin and allied drugs, the production of agglutins in the blood of cholera cases, and the existence of cholera-like vibrios in the tissues side by side with the true cholera vibrio.

Kala Azar.—Major F. P. Mackie, I.M.S., was engaged on a special study of Kala Azar until his recall to military duty at the end of November 1914. The results that had been so far gained were mostly of a negative character but none the less valuable, as going to show that the disease in India is not associated with a general infection of the Indian dog by the *Leishmania* parasite and that in this respect the problems of the conveyance of the disease in India differ from those presented in the Mediterranean littoral.

Dysentery.—Military exigencies have interfered with the course of the inquiry into this disease, which was being conducted by Captains J. Cunningham and H. H. King of the Indian Medical Service, and work has had to cease for the present.

Goitre.—Major McCarrison, I.M.S., continued his researches into this subject until his recall to military duty in November 1914. He has published three reports during the year, which along with former reports have attracted considerable attention and have gained for Major McCarrison the Fellowship of the Royal College of Physicians of London and the Prize Annisfort of the Académie de Medicine of Paris.

Leprosy.—Observations on the etiology and treatment of this disease continued to be made by Lieutenant-Colonel Gwyther, I.M.S., in the Leper Asylums at Purulia, Sabathu and Srinagar, until November 1914 when the investigation was brought to a close.

Tuberculosis.—From May 1914 Dr. Lankester was placed under the Research Fund Association on special duty for the study of tuberculosis in India. He has toured throughout the greater part of the country, devoting his attention to the epidemiology of tuberculosis in India and the willingness of individuals to co-operate in diminishing its prevalence. The assistance and co-operation received by Dr. Lankester at the hands of Local Governments and individuals have been most encouraging as evidence of the interest now being shown in India in matters of public health. It is confidently anticipated that Dr. Lankester's report will contain information that will greatly help to initiate anti-tuberculosis campaigns in India.

Pharmacology of Cinchona Derivatives.—A careful study of the efficacy of the various Cinchona derivatives in the treatment of Malaria by Major Mac Gilchrist, I.M.S., has been brought to a satisfactory conclusion. His experiments prove amongst other things the value of certain salts of Cinchona alkaloids other than quinine in the treatment of Malaria.

Plague prevention.—The importance of places infected with plague late in the epidemic season as *foci* in which infection is carried over from one epidemic season to the next has been investigated by Major Kunhardt, I.M.S., who has given special attention to the Poona, Satara, Sholapur and Ahmednagar districts of the Bombay Deccan, a region in which Major Kunhardt maintained such *foci* played an all-important part. Although so far definite conclusions have not been reached, an increase of our knowledge of the relative value of different anti-plague measures commonly employed may be confidently expected.

Bacteriological Examination of water.—With the object of attempting to fix suitable bacteriological standards for Indian water supplies, an investigation—with Captain Morrison, I.M.S., in charge—was started at Poona, where the water supply from the lake offers numerous and complex problems. Very valuable work has already been accomplished and it has been established that the water supply is the cause of the intestinal disorders for the prevalence of which Poona has had so long an unenviable reputation.

Diabetes.— An investigation into the prevalence and etiology of diabetes in India is being made by Major D. McCay, I.M.S., of the Medical College, Calcutta.

Entomological work.—Mr. P. R. Awati, was attached to Major Greig's cholera inquiry in Calcutta for some months to study the question of the common house fly as the " porter " of cholera infection. It became evident however that in our present imperfect knowledge of the differentiation of species and the bionomics of house flies, a restriction of the inquiry to the original lines would not have yielded results of value. Accordingly Mr. Awati is now investigating the larger problem on original lines, with the aid of one of the entomological assistants under the Research Fund Association.

Ankylostomiasis or Hookworm disease.—Major Clayton Lane, I.M.S., has written a popular account of this disease, and his pamphlet has been largely in demand.

Anopheline Mosquitos of Aden.—The Sub-Assistant Surgeon attached to the Central Malaria Bureau at Kasauli was deputed to make a collection of the Anopheline mosquitos of Aden. He brought back a large collection, the working out of which has enabled the anophelines of Aden to be correctly identified. This work has a direct practical interest now that we have forces engaged in Arabia and Persia.

Snake venoms and Rabies.—Investigations have been and are being made at the Pasteur Institute, Kasauli, on snake venoms and on rabies. Reports on the former inquiry have been published by Captains Acton and Knowles of the Indian Medical Service.

APPENDIX.

Report on the work conducted for India at the Imperial Institute during the year ended 30th June 1915.

SCIENTIFIC AND TECHNICAL RESEARCH DEPARTMENT.

I.—SCIENTIFIC INVESTIGATIONS.

Aconites.—The following species of Indian aconites have been under investigation during the year : *Aconitum laciniatum*, *A. heterophylloides*, *A. concatenatum*, *A. palmatum*, and a hybrid *A. spicatum* × *A. laciniatum*. The alkaloids of all these species have been isolated and submitted to a preliminary examination, and a sufficient supply of each is being prepared for complete chemical and physiological investigation. Attention is being devoted in the first place to the alkaloid of *Aconitum concatenatum*.

Opium.—The question of the utilisation in Europe of Indian opium for medicinal purposes and the manufacture of alkaloids has received considerable attention throughout the year in communication with the India Office.

Drugs.—A chemical examination was made of the flower-heads of the " Zher " and " Tirkha " plants from Baluchistan, believed to be species of *Artemisia*, in order to ascertain whether they contained santonin. In both cases the investigation gave negative results. Incidentally, however, the identity of the two plants has been definitely established at Kew from the specimens supplied to the Imperial Institute. " Zher " is not a species of *Artemisia* as was supposed, but *Tanacetum fruticulosum* Ledeb., whilst " Tirkha " is *Artemisia Herba-alba* Asso.

Essential Oils.—A sample of deodar oil, obtained from waste deodar wood, was forwarded from India for examination in order that its uses and value might be determined. The oil is quite unknown in commerce, and it was consequently found necessary in the first instance to determine its constituents. This work was still in progress at the end of the year.

A similar investigation of the constituents of the volatile oil derived from the oleo-resin of *Boswellia serrata* was also commenced during the year.

The oleo-resin of *Hardwickia pinnata* was examined chemically at the Imperial Institute and submitted to therapeutical trials as a possible substitute for balsam of copaiba. A report on the results of the investigation is given in the " Bulletin of the Imperial Institute," Vol. XIII (1915), No. 1 page 41. The therapeutical value of the oleo-resin appears to be doubtful.

Herbarium specimens of the " white-stemmed " and " red-stemmed " lemongrass from Travancore and Cochin, supplied to the Imperial Institute in continuation of a previous investigation of the oils from the two varieties

of grass, were pronounced at Kew to all belong to the same species, *Cymbopogon flexuosus* Stapf. The two forms represent slightly different colour variations but structurally they are identical.

Beans.—Samples of Madagascar beans grown experimentally in Burma from seed supplied by the Imperial Institute were examined in order to ascertain whether the amount of prussic acid yielded by the beans shows any increase when they are cultivated in that country. The results of these experiments show a progressive increase in the small amounts of prussic acid yielded by Madagascar beans when cultivated in Burma, and it will be of interest to determine the effect of further cultivation.

A similar investigation was carried out with four samples of native Burmese beans (Kawl-be, red) obtained in the course of experiments conducted with a view to isolating pure races of these beans. The samples were found to yield from 0·034 to 0·038 per cent. of prussic acid, whereas a previous sample of ordinary red Kawl-be beans forwarded to the Imperial Institute from Burma yielded 0·05 per cent.

Monazite.—A sample of green mineral received from Southern India was proved by analysis to be monazite. It contained unusually large percentages of thoria and uranium oxide. A complete examination of this monazite is being made.

II.—TECHNICAL AND COMMERCIAL INVESTIGATIONS.

A.— Experimental Work.

Cotton.—Samples of three varieties of cotton (Cambodia, Rosea, and a hybrid Deshi-Lahore and Bani) which were stated to have given some promise of success when grown under irrigation at the Experimental Farm, Sindewahi, Central Provinces, were submitted for examination. The Cambodia cotton was of satisfactory quality except for a little irregularity in length and strength ; the Rosea cotton was of fairly good quality but its value was diminished by the presence of stains ; the Deshi-Lahore and Bani cotton was on the whole of fair quality but somewhat lacking in strength. The three samples were valued respectively at 5 ¾*d*., 4¼*d*., and 5¼*d*. per lb., with "middling" American at 5·63*d*. per lb.

Fibres.—A sample of plantain fibre from Burma was found to be much inferior in quality to a previous specimen from the same source. It was valued at £10 to £12 per ton in London (July 1914), and it is improbable that fibre of this grade would be worth exporting.

A sample of "Kayoon" fibre from Southern India consisted of ribbons of partly prepared fibre, which was of fair colour, lustre and softness. The fibre was much interlaced and consequently would be difficult to spin, but it might be utilised for mixing with jute when the price of the latter is high. The cultivation of the fibre in India for export could, however, not

be recommended. The sample was valued at about £8 per ton c.i.f. London (March 1915).

Seven samples of "Ak" fibre, obtained in the course of experiments conducted in Sind, were forwarded for examination and valuation. All the samples were of good appearance and strength, but their short and irregular staple detracted from their commercial value. The samples were valued at from £24 to £28 per ton in London (July 1914). The Imperial Institute subsequently made recommendations regarding a suitable machine for trial in India for preparing the fibre, as it was stated to be impossible to extract the material in commercial quantities by hand.

Rubber.—Two samples of Castilloa rubber derived from male and female trees growing in the Bassein Botanical Gardens were received for examination. The rubber from the male trees was much superior in composition to that from the female trees containing 12·4 per cent. of resin as compared with 34·3 per cent. in the latter, and it was also more satisfactory in physical properties. The samples, however, were not of very high quality, and the rubber from the male trees was valued at about 1*s*. 6*d*. per lb., and that from the female trees at about 1*s*. 3*d*. per lb. in London, with fine hard Para at 2*s*. 6*d*. per lb. and fine plantation Para at 2*s*. 4*d*. per lb.

Feeding-stuffs.—Three samples of Madagascar beans which had been grown experimentally in Burma were received for examination and valuation. The beans were of good quality but inferior to the original seed beans in colour, appearance and size ; they were valued at from 16*s*. to 20*s*. per cwt. in normal times, but in the exceptional circumstances arising out of the war they would probably realise up to 26*s*. to 28*s*. per cwt. in London (February 1915).

A sample of native Burmese beans (*Canavalia* sp.) was very similar in composition to specimens of Canavalia beans previously examined at the Imperial Institute. These beans are not an article of commerce in the United Kingdom at present and a market would have to be created for them in the first instance. Merchants reported that if the beans were found to be suitable for edible use they would possibly realise from £9 to £10 per ton c.i.f. United Kingdom ports (December 1914), but that if they could only be used as a feeding stuff for animals they would not fetch more than from £5 to £6 10*s*. per ton.

A sample of the residual cake obtained on expression of the fat from the seeds of *Schleichera trijuga* was found to possess only a moderate feeding value, below the average for undecorticated cotton-seed cake, and it yielded a small quantity of prussic acid. For these reasons it could not be recommended for feeding purposes and it would have little value as a manure, being deficient in nitrogen and phosphoric acid. It is, therefore, very unlikely that this cake could be sold at a remunerative price in the United Kingdom.

Oilseeds.—The fat prepared from the seeds of *Schleichera trijuga* was found to be unsuitable for edible purposes, whilst owing to various technical

difficulties it appeared very doubtful whether it could be satisfactorily employed in soap-making. A provisional valuation of £20 per ton in the United Kingdom was obtained for the fat, but it seems unlikely that it would meet with a ready sale. In these circumstances the preparation of the fat for export cannot be recommended.

Essential Oils.—A small consignment of cus-cus (vetiver) roots from Trichinopoly, forwarded in continuation of a previous enquiry, was found to yield on distillation only 0·17 per cent. of oil of inferior fragrance. In view of the small yield of oil the roots would only realise a low price and would be less likely to be marketable in Europe than a previous sample which gave a yield of 0·26 per cent. of oil.

Gum.—A small sample of gum from the Central Provinces was of a type which when nearly colourless can be used as a substitute for tragacanth, and may be worth in normal times about £2 10*s*. per cwt. A larger representative sample was requested for examination and valuation.

Tanning Material.—A sample of myrabolans from Mysore was found to consist of a mixture of one-third of unsound nuts worth about 5*s*. 6*d*. per cwt. and two-thirds of sound nuts worth about 8*s*. per cwt. Recommendations were made as to the best methods of grading the nuts for the United Kingdom market and general information was supplied as to the demand for stoned and crushed myrabolans.

Minerals.—Eight samples of clay from Jhalawar were examined. It was found that they might be used for the manufacture of Portland cement in conjunction with a suitable limestone, and that some of them would be suitable for making pottery.

B.—The Technical Information Bureau.

During 1914 a Technical Information Bureau was formed at the Imperial Institute for the special purpose of dealing with the steadily increasing stream of technical and commercial enquiries which have been received in recent years from manufacturers, merchants and others in the United Kingdom, the Colonies and India. These enquiries relate principally to new sources of supply of raw materials, methods of utilising new products from the Colonies and India, or to new or little known processes and machinery for industrial purposes.

The efforts of the Technical Information Bureau during the period covered by this report have been mainly directed to finding new markets, particularly in the United Kingdom, for various raw materials which were formerly exported to the Continent but which were affected by the general dislocation of European trade due to the war. A large amount of this work related to India and Indian products.

Four of the raw materials dealt with, *viz.*, groundnuts, copra, ajowan seed and dari are worthy of particular notice in this report.

Groundnuts.—At the present time India is the largest producer of groundnuts in the world, the exports in 1913-14 amounting to 5,558,120 cwts., valued at £3,254,247. More than four-fifths of this quantity was shipped to France, there to be used for the manufacture of groundnut oil and ground nut cake. In consequence of the situation created by the war, the demand for groundnuts in France fell much below the normal and it was therefore necessary that new markets should be found for the Indian crop. The total amount of groundnuts hitherto imported into the United Kingdom has been comparatively small, so that there is ample scope for extension of the groundnut crushing industry in this country. With a view to calling the attention of manufacturers, merchants, and others to the possibilities of the industry, the Technical Information Bureau prepared a notice on the subject which was widely circulated in the Press, whilst some hundreds of copies of a more detailed circular, were distributed to firms likely to be interested in the product. As a result of this work a large number of enquiries were received by the Bureau, and many firms were put in touch with exporters of Indian groundnuts or their London agents. Information has already been received to the effect that certain oil-seed crushers in the United Kingdom have decided to undertake the manufacture of groundnut oil and cake. The attention of the public was also drawn to the value of groundnuts as a food, for which purpose the better qualities of Indian nuts are quite suitable, and from the numerous enquiries which have been received, it would appear that their use in this way will probably be considerably extended.

Copra.—Similar action was taken in the case of copra, a product which in the past has been mainly shipped to Germany. Notices were issued to the Press, a circular was widely distributed to manufacturers, merchants and others, and an article on "the Industrial Position of Copra, Coconut Oil and Coconut Cake" was published in the "Bulletin of the Imperial Institute," Vol. XII (1914), No. 4, pp. 557—577. In this case also many firms in this country were put into communication with Indian exporters, and several British oil mills are now engaged in the manufacture of coconut oil and cake.

Ajowan Seed.—Considerable attention was devoted to the subject of thymol. Hitherto almost the entire supply of thymol has been prepared in Germany from ajowan seeds imported into that country from India. As a result of a notice communicated to the Press by the Bureau, a large number of firms expressed interest in the subject, and with a view to considering the manufacture of thymol in this country, they were furnished, at their request with information as to the method of its preparation, and with names of Indian exporters of ajowan seed. Attention was also directed to the subject in an article in the "Bulletin of the Imperial Institute," Vol. XII (1914) No. 4, pp. 599—605.

Dari.—In view of the enhanced prices of cereals commonly used for poultry food, attention was drawn to the merits of dari, the seed of *Sorghum vulgare*, which is already imported into the United Kingdom from India. A

notice on this subject was communicated to the press and as a result a large amount of interest was aroused. Numerous enquiries were received, and, in response, information was furnished on the feeding value of dari, its suitability for fowls of different ages, and the addresses of firms (both wholesale and retail) capable of supplying the grain.

Several hundred enquiries relating to India and Indian products were dealt with. Amongst a large number of miscellaneous enquiries not mentioned above, reference may be made to enquiries relating to mowra seed, piney tallow, indigo, kapok, lac waste, refuse mica, paper-making materials and machinery for the manufacture of tapioca and other products.

Information was also furnished to Indian Government Departments in connection with various technical and commercial matters, including the following :—The marketing of sandalwood ; the utilisation of Indian opium for medicinal purposes in Europe ; the marketing of cinchona bark ; the demand for Indian edible oils ; the marketing of Indian hides and skins, Indian senna, and Indian fibres ; the preparation of mangrove extract ; machinery for the stoning of myrabolans ; the market for cotton seed cake in the United Kingdom ; machinery suitable for cutting chank shells ; the preparation and marketing of meerschaum ; beans suitable for cultivation in Burma ; the utilisation of *Sida* and *Urena* fibres ; the deodorisation of fish oils ; and the hydrogenation of oils.

List of materials received at the Imperial Institute from Government Officers in India during the year ended 30th June 1915.

Title of Officer.	Material sent.	Number of samples.
Director-General of Commercial Intelligence, Calcutta.	Kayoon fibre	1
Economic Botanist to Botanical Survey	"Zher," *Tanacetum* sp.	2
Do. do.	"Tirkha," *Artemisia* sp.	2
Do. do.	Vetiver roots	1
Forest Economist, Dehra Dun	*Hardwickia pinnata* resin	1
Under Secretary to Government of Bombay.	Castilloa rubber	2
Director of Agriculture, Central Provinces.	Cotton	7
Director of Agriculture, Burma	Madagascar beans	3
Do. do.	Native beans	5
Director of Agriculture Madras	Lemongrass	4
Do. do.	Soya beans	1
Deputy Director of Agriculture, Southern Circle, Central Provinces.	Cotton	3
Do. do. do.	Gum	1
Deputy Director of Agriculture, Sind	Ak stalks and fibre	2
Director of Industries, Madras	Groundnuts	3
Hon. Director of Fisheries, Madras.	Chank shells	1
Superintendent, Government Opium Factory, Ghazipur.	Morphine and codeine	10
Do. do. do.	Opium	80
Agents for the Government of Mysore	Myrabolans	1

List of Reports made by the Imperial Institute to Government Officers in India during the year ended 30th June 1915.

Officers to whom Reports were sent.	Subject of Reports.
Director-General of Commercial Intelligence, Calcutta.	Plantain fibre.
Do. do. do.	Cotton-seed cake.
Do. do. do.	Sandalwood.
Do. do. do.	Kayoon fibre.
Director of the Botanical Survey	"Zher," *Tanacetum* sp.
Do. do.	"Tirkha," *Artemisia* sp.
Do. do.	Vetiver roots.
Forest Economist, Dehra Dun	Deodar oil.
Do. do.	*Boswellia serrata* resin.
Do. do.	Do. turpentine oil.
Do. do.	Mangrove extract.
Fibre Expert to the Government of India	*Sida* and *Urena* fibres.
Under Secretary to the Government of Bombay	Ak fibre.
Do. do. do.	Castilloa rubber.
Secretary to the Government, Madras	Sandalwood.
Do. do.	Cinchona bark.
Director of Agriculture, Madras	Lemongrass.
Do. Burma	Madagascar beans.
Do. do.	Native beans.
Director of Agriculture, Bihar and Orissa.	Indian hides.
Deputy Director of Agriculture, Southern Circle, Burma.	Smyrna beans.
Deputy Director of Agriculture, Southern Circle, Central Provinces.	Cotton.
Do. do. do.	Gum.
Deputy Director of Agriculture, Sind	Ak fibre.
Director of Industries, Madras	Edible oils.
Do. do.	Hides and skins.
Do. do.	Senna.
Do. do.	Fibres.
Hon. Director, Madras Fisheries	Fish oils.
Do. do.	Gheeline.
Do. do.	Chank shells.
Agent for the Government of Mysore	Myrabolans.

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Departmental Publications.

I.—METEOROLOGICAL DEPARTMENT—

Government of India Office.

(1) The Indian Daily Weather Report and Chart.

(2) The Weekly Rainfall Summary.

(3) The Monthly Weather Review.

(4) The Annual Summary.

(5) The Rainfall of India.

(6) Indian Meteorological Memoirs.

Bengal Office.

(1) Bengal Daily Weather Report and Chart.

(2) Monthly Rainfall Tables and Summaries of the chief feature of the weather of the month over Bengal.

Bombay Office.

(1) Bombay Daily Weather Report and Chart.

(2) Monthly Abstracts of the Bombay observations (*Bombay Gazette*).

Madras Office.

(1) Bombay Daily Weather Report and Chart.

(2) Monthly Rainfall Tables (*Madras Gazette*).

Allahabad Office.

(1) Monthly Weather Summaries (*United Provinces Gazette*).

(2) Annual Summary.

(3) Monthly Rainfall Tables (*United Provinces Gazette*).

Lahore (Simla) Office.

(1) Monthly Summary } of Punjab weather.
(2) Annual Summary } of Punjab weather.

II.—GEOLOGICAL SURVEY.

The publications of the Department include—

Palæontologia Indica arranged in series, and sold in parts which are priced at 4 annas (6 pence) per plate.

Memoirs, Vols. I—XLI, including the larger papers on geological subjects.

Records, Vols. I—XLVI, including the shorter papers and Annual Reports from 1868 to 1915, sold in parts, price one rupee each.

Manual, Guides and Maps.

A complete list of the contents of these publications can be obtained by application to the Registrar, Geological Survey of India, 27, Chowringhee Road, Calcutta.

Indexes to the Genera and Species described in the *Palæontologia Indica* up to 1891, to the Memoirs, Vols. I—XX, and to the Records, Vols. I—XXX, have been printed for sale.

III.—SURVEY OF INDIA.

(1) Annual General Report.

(2) Professional Papers.

IV.—BOTANICAL SURVEY AND ROYAL BOTANIC GARDEN, CALCUTTA.

(1) Annual Report of the Botanical Survey of India.

(2) Records of the Botanical Survey, Vols. I—VIII.

(3) Annual Report of the Industrial Section, Indian Museum.

(4) Annual Report of the Royal Botanic Garden, Calcutta.

(5) Annals of the Royal Botanic Garden, Calcutta, Vols. I—XII.

A list of the contents of the Records and of the Annals with prices of the numbers and volumes still available can be obtained by applying to the Superintendent, Royal Botanic Garden, Calcutta.

V.—DEPARTMENT OF AGRICULTURE.

(1) Annual Report.—An account of the year's work of the Imperial Department, including the separate reports of the scientific officers of each branch (Agricultural Chemistry, Botany, Mycology, Entomology, and the like).

(2) The Agricultural Journal of India.—A quarterly journal containing articles on agricultural matters intended for the educated agriculturist and the general reader interested in Agriculture.

(3) Scientific Memoirs of the Department of Agriculture.—An occasional publication for papers of a scientific or technical nature divided into series such as Chemical, Botanical, Entomological, and the like.

(4) Bulletin.—An occasional publication containing information on agricultural matters of a temporary nature.

(5) Leaflets.—Short notes of practical instruction in agricultural matters, dealing mainly with entomological subjects.

VI.—FOREST DEPARTMENT.

(1) Review of Forest Administration in British India by the Inspector-General of Forests (issued annually).

(2) Annual Progress Report of Forest Administration in each Province.—Issued by the Local Governments annually.

(3) Indian Forest Records.

(4) Indian Forest Memoirs.

(5) The Indian Forester.—A monthly Journal of Forestry, Agriculture, Shikar and Travel. This is a Departmental Journal, published monthly.

(6) Bulletins are published from time to time.

VII.—ZOOLOGICAL DEPARTMENT.

(1) The Annual Report, 8vo.

(2) The Records of the Indian Museum, 8vo. Containing short papers on Indian zoology. One or two volumes issued annually in quarterly parts.

(3) The Memoirs of the Indian Museum, 4to. Containing monographs and other important papers. Published at irregular intervals.

(4) Descriptive Catalogue of Indian Decapod Crustacea, 4to. Parts published at irregular intervals.

(5) Descriptive Catalogue of Indian Echinodermata, 4to. Parts published at irregular intervals.

VIII.—CIVIL VETERINARY DEPARTMENT.

(1) Annual Report.

CALCUTTA : PRINTED BY SUPDT. GOVT. PRINTING, INDIA, 8, HASTINGS STREET.